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1	.228	21	.159	41	.096
2	.221	22	.157	42	.093
3	.213	23	.154	43	.089
4	.209	24	.152	44	.086
5	.205	25	.149	45	.082
6	.204	26	.147	46	.081
7	.201	27	.144	47	.078
8	.199	28	.140	48	.076
9	.196	29	.136	49	.073
10	.193	30	.128	50	.070
11	.191	31	.120	51	.067
12	.189	32	.116	52	.063
13	.185	33	.113	53	.059
14	.182	34	.111	54	.055
15	.180	35	.110	55	.052
16	.177	36	.106	56	.046
17	.173	37	.104	57	.043
18	.169	38	.101	58	.042
19	.166	39	.099	59	.041
20	.161	40	.098	60	.040

Tap Size	Tap Drill	Clearance Drill	Tap Size	Tap Drill	Clearance Drill
14x20	No. 10	¼	8x32	No. 28	18
14x24	No. 6	¼	7x32	No. 30	22
12x24	No. 15	1	6x32	No. 33	27
11x24	No. 19	3	5x40	No. 36	29
10x24	No. 23	9	4x36	No. 41	31
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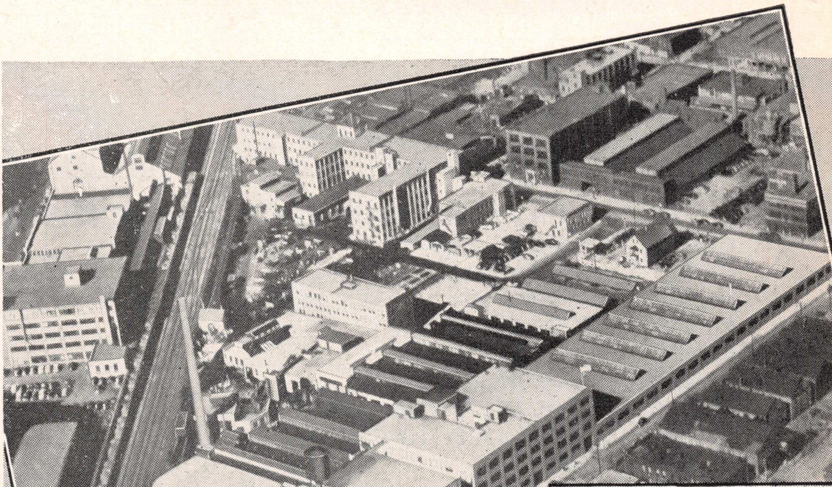

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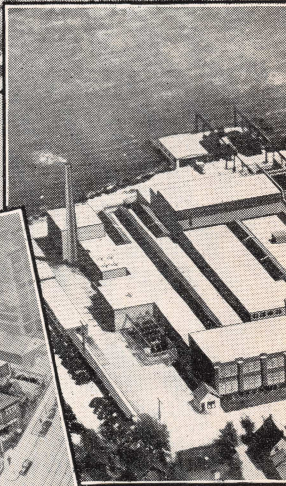

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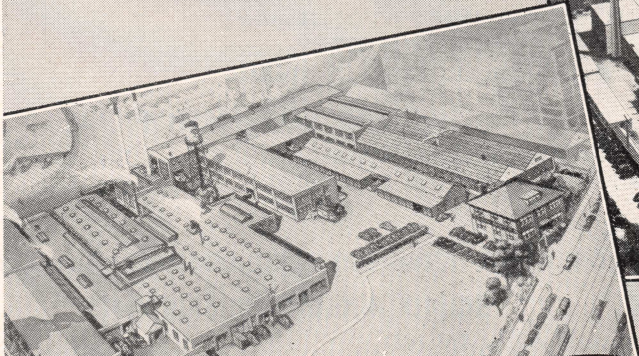

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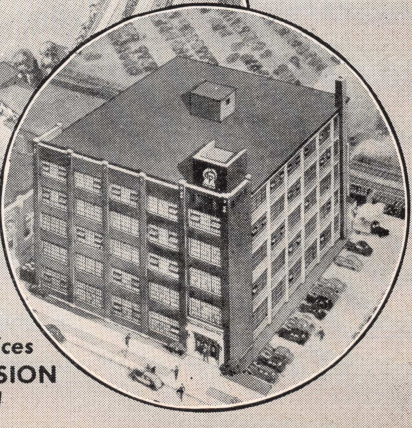

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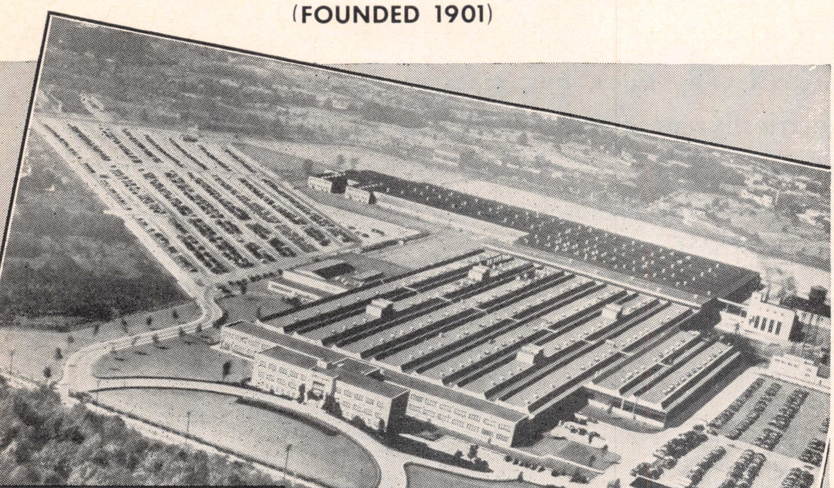

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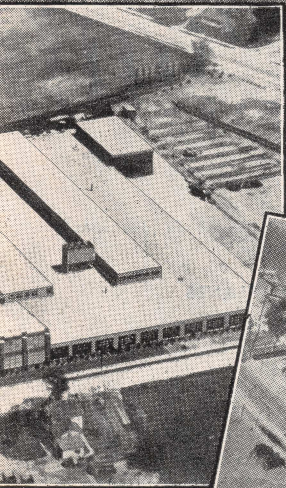

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PISTON PINS
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PISTON RINGS

ENGINE BEARINGS

CONNECTING RODS
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Wet and Dry

CYLINDER SLEEVE ASSEMBLIES

WATER PUMPS

WATER PUMP PARTS

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KING BOLT SETS

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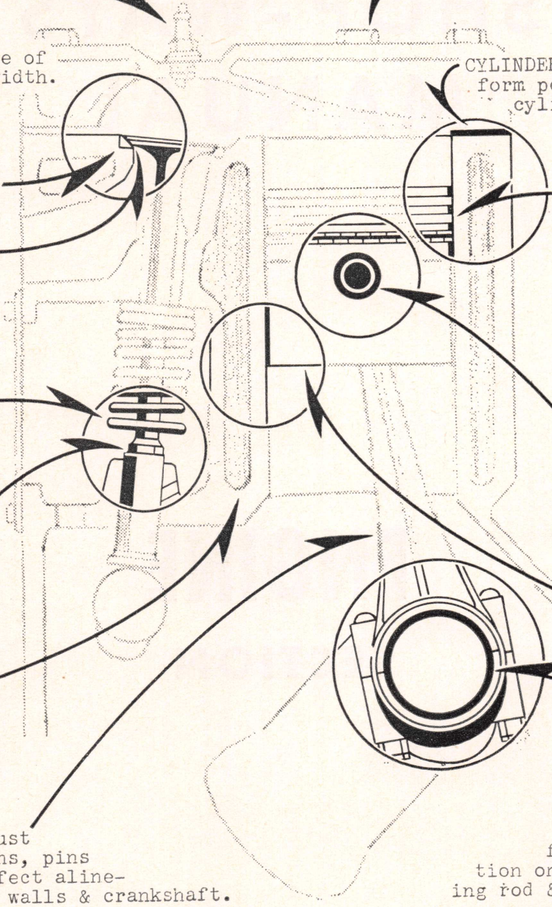
Thompson
SHOP-WAYS MANUAL

ENGINE
SECTION

ENGINE POWER

MAXIMUM POWER Available in any Engine is the result of Perfect Team-Work of all Engine Parts that contribute to Compression, Combustion & Friction Free Action.

"MUSTS" for POWER



IGNITION: Spark (gasoline engines), fuel injection (diesel engines) must occur at proper piston position.

VALVE SEATS: Must be of specified angle & width. Top edge of seat should contact valve face within 1/64" of outer edge of valve face.

VALVE FACE: Must be smooth & of specified angle.

FUEL & AIR: Must be properly mixed.

VALVE SPRINGS: Must have proper tension to return & hold valves to seats.

VALVE TAPPETS: Must be adjusted to specified running clearances.

WATER JACKETS: Must be clean throughout allowing free flow of coolant.

CONNECTING RODS: Must be alined so pistons, pins & rings are in perfect alinement with cylinder walls & crankshaft.

CYLINDER HEAD BOLTS: Must be tightened in proper sequence & to recommended torque tightness.

CYLINDER HEAD GASKET: Must form perfect seal between cylinder head & block.

PISTON RINGS: Must contact cylinder walls with proper tension to hold high pressures & to transfer heat to cylinder walls with minimum friction.

PISTON PINS: Must be fitted to pistons & bushings to allow free wrist action with minimum friction & play.

PISTONS: Must be fitted to cylinder bores with recommended clearance.

BEARING CLEARANCES: Must allow specified radial & end clearances for smooth, quiet, friction free operation on all main, connecting rod & camshaft bearings.

REASONS WHY

On the POWER STROKE, pressures & temperatures are built up to HIGH VALUES in the combustion chambers. All pressures & some of the HEAT must be held above the pistons. Piston rings must hold these pressures & transfer excessive heat to cylinder walls.

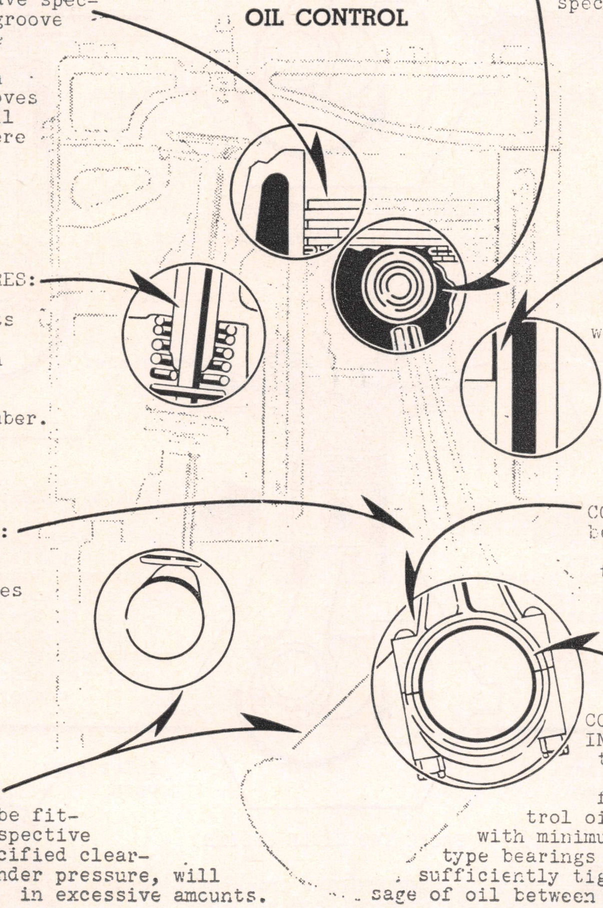
It is obvious then that valve assemblies, piston assemblies, oiling system, cooling system & engine tuning must be in perfect ADJUSTMENT & ALINEMENT & the cylinder head gasket must form a perfect SEAL, if these pressures are to be controlled. "PRESSURE" is "POWER".

ENGINE OIL CONTROL

OIL CONTROL means the RIGHT amount of oil for proper lubrication, at the right places at the right time. EXCESSIVE oil expelled into the crankcase will result in engine FOULING & OIL WASTE. Too little oil will cause rapid WEAR & RUINED parts.

PISTON RINGS play the most important part in oil control, but, they can not do the job alone. Distribution of oil to numerous engine parts must be CONTROLLED by FIT of bearings, ALINEMENT of connecting rods and various other parts used in modern engines.

"MUSTS" for OIL CONTROL



PISTON RINGS: Must fit squarely against cylinder walls; have specified ring to groove clearance; have specified gap; be installed in clean ring grooves having clear oil drain holes where used.

PISTON PINS: Must be fitted to pistons & bushings with specified clearances to allow proper piston expansion & contraction, to control oil flow (particulary on rifle drilled rods).

VALVE GUIDE BORES: Must be within specified limits to allow free valve operation & prevent oil passing into combustion chamber.

PISTON FIT TO CYLINDER: Must be held to specified limits allowing skirt to wipe excess oil from cylinder walls with minimum friction.

CONNECTING RODS: Must be alined to hold piston & ring assemblies in alinement with cylinder walls & crankshaft.

OIL SQUIRT HOLE IN CONNECTING ROD: Must be positioned so oil is discharged to thrust side of cylinder.

MAIN & CAMSHAFT BEARINGS: Must be fitted to their respective journals to specified clearances so oil, under pressure, will not be expelled in excessive amounts.

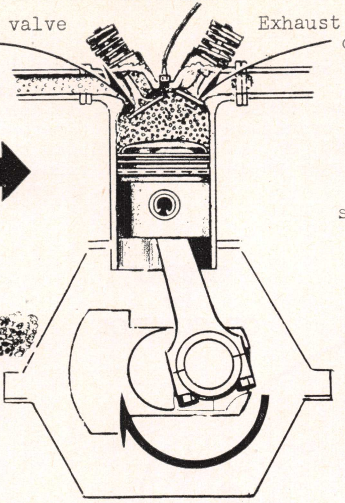
CONNECTING ROD BEARINGS: Must be fitted to crankshaft journals within specified limits to control oil, under pressure, with minimum friction. Insert type bearings must fit rod bores sufficiently tight to prevent passage of oil between insert & rod bore.

REASONS WHY

On the INTAKE stroke, normal PRESSURES are greatly decreased ABOVE, & slightly increased BELOW, the pistons. The piston assemblies (pistons, pins & rings) & valve assemblies (valves, guides & seats) are SEALS that prevent oil vapors from working into the combustion chambers.

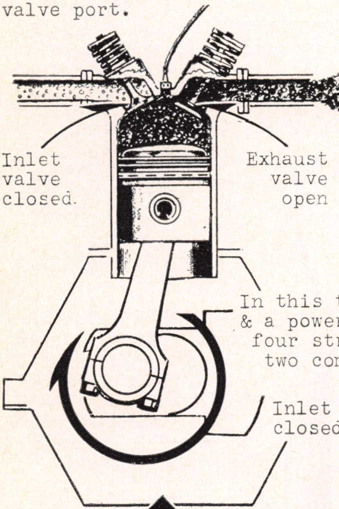
Even when the PISTON & VALVE assemblies are in perfect condition, EXCESSIVE OIL thrown around by improperly fitted main bearings, connecting rod bearings, camshaft bearings or misalined connecting rods, will work its way into the combustion chambers, resulting in oil waste.

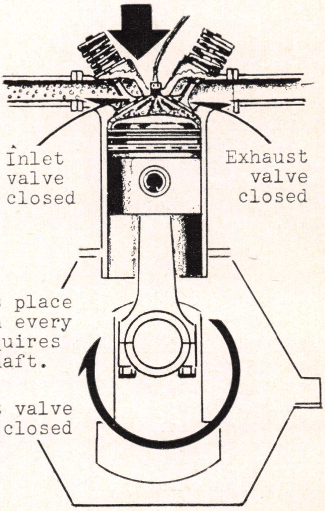
ENGINE CYCLES



CYCLE 1, INTAKE: Starter rotates the crankshaft, moving piston "down" in cylinder, which draws in metered mixture of air & fuel through open inlet valve port.

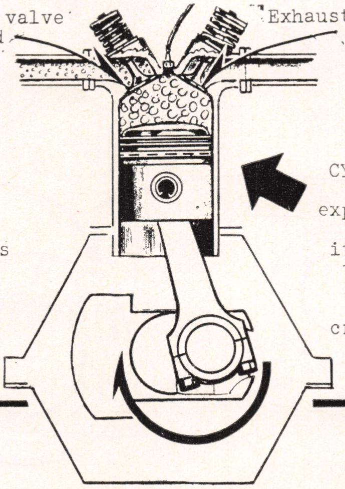
CYCLE 2, COMPRESSION: Cylinder is fully charged with fuel mixture & piston moves "up" to top of compression stroke where ignition occurs & combustion starts





BASIC FOUR CYCLE ENGINE

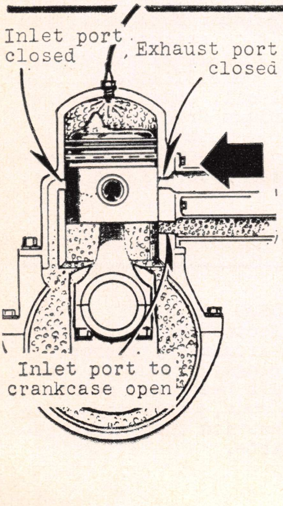
In this type engine, combustion takes place & a power impulse is obtained once in every four strokes of the piston, which requires two complete revolutions of crankshaft.



CYCLE 4, EXHAUST: Continued rotation of the crankshaft moves the piston "up" into the exhaust or scavenging stroke, where the burnt gases move out of the cylinder through the open exhaust port. As piston reaches top, exhaust valve closes & inlet valve opens to again start Cycle 1.

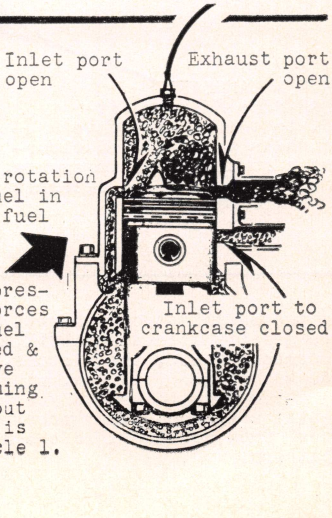
CYCLE 3, POWER: Under combustion, fuel mixture rapidly expands & exerts high pressure on the piston head, causing it to move "down" & away from the stationary cylinder head. This is the "POWER" stroke that is transmitted to the crankshaft by the connecting rod; reciprocating movement converted to rotary.

BASIC TWO CYCLE ENGINE



CYCLE 1, COMPRESSION: Crankshaft rotation moves piston "up", compression fuel in combustion chamber. Piston opens fuel inlet port to crankcase.

CYCLE 2, POWER: Expansion of compressed fuel mixture when ignited, forces piston "down" on power stroke. Fuel mixture in crankcase is compressed & by-passed up & into cylinder above the piston. Pressure of the incoming fuel mixture forces burnt gases out through the exhaust port. Piston is ready to enter "up" stroke of Cycle 1.



PRELIMINARY TESTS

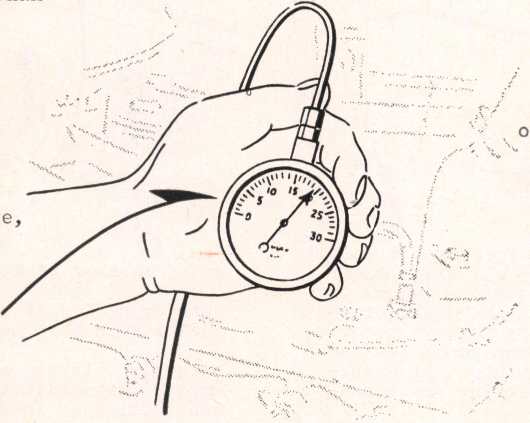
Engine performance is governed by several factors, therefore, to correct engine failure, it is good practice to perform a few preliminary tests to isolate the causes, before motor repair operations are started.

TEST MANIFOLD PRESSURE

Manifold pressure often referred to as vacuum, must be within specified limits.

To test manifold pressure, run engine until normal operating temperature is obtained.

Attach pressure gage, or vacuum gage, to intake manifold & with engine running at idle speed, observe gage reading.



Gage reading should be steady & within specified limits.

A low steady gage reading indicates leakage by the piston rings.

Excessive fluctuation of gage hand indicates defective valve action, broken cylinder head gasket, broken piston rings on one or more pistons or other defects that interrupt manifold pressure.

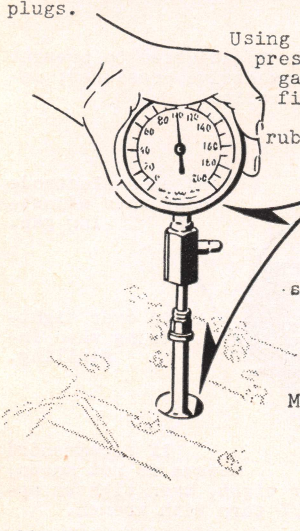
Conditions indicated by tests should be noted so corrections can be made.

TEST COMPRESSION PRESSURES

Compression pressures must be within specified limits on all cylinders.

To test, blow or brush all dirt from spark plug wells & remove all spark plugs.

Using suitable compression pressure gage, hold gage firmly in spark plug holes so rubber tip seals hole.



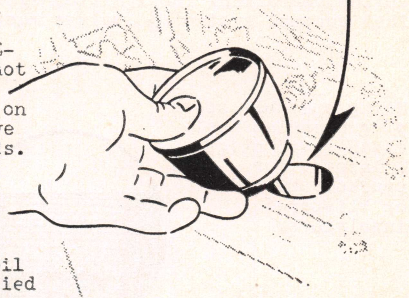
Rotate crankshaft several times with starter (choke & throttle open).

Make record of highest reading for each cylinder.

Consult engine manufacturers specifications for compression pressure limits.

To isolate cause of low compression, apply light coat of engine oil to top of piston & recheck pressures.

NOTE- Do not get oil on valve heads.



If oil applied to top of piston materially increases compression pressures, faulty piston rings are indicated.

TEST FOR BLOW-BY

BLOW-BY, a product of poorly seated piston rings, is gas under pressure of combustion passing rings into crankcase. Oil dilution, engine heating, collapsed pistons & in extreme cases scored pistons are result of blow-by.

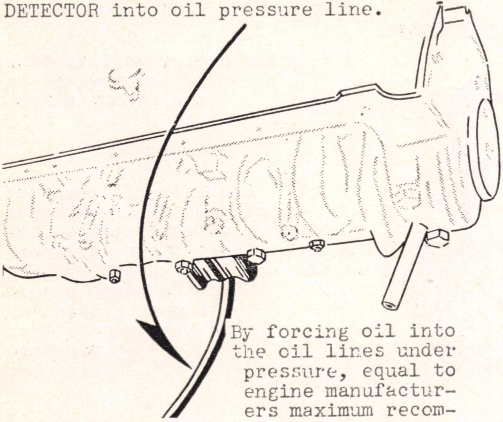
Blow-by is indicated by excessive smoke & engine noises emanating from filler pipe. If noises can be stopped by covering filler pipe with palm of hand, blow-by is indicated. Oil fumes in car also indicate blow-by.

PRELIMINARY TESTS

TEST FOR OIL LEAKS

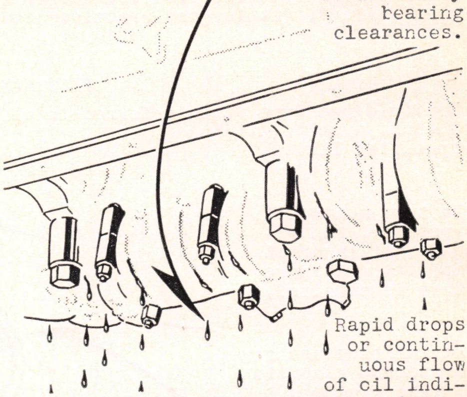
Make oil leak tests, internal & external, before disassembling engine.

Remove oil pan & connect BEARING LEAK DETECTOR into oil pressure line.



By forcing oil into the oil lines under pressure, equal to engine manufacturers maximum recommended pressure, bearing condition can be determined by amount of oil expelled from main, connecting rod & camshaft bearings.

Slow metered drops of oil indicates satisfactory bearing clearances.



Rapid drops or continuous flow of oil indicates worn or broken bearing surfaces.

Note condition of oil. Diluted oil may indicate faulty fuel pump.

Excessive sludge around the inside of engine may indicate faulty crankcase ventilation or internal water leak.

RESULT OF TEST

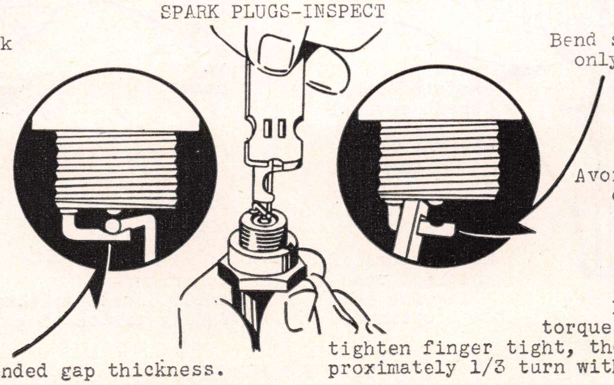
The preliminary tests just completed, should give fair knowledge of necessary repairs (engine tune-up, valve reconditioning or engine overhaul).

TUNE-UP

Engine tune-up plays a vital part in engine operation. The ignition system, fuel control system & valves must be properly timed & adjusted to prevent oil dilution; excessive pressures; uneven engine operation.

SPARK PLUGS-INSPECT

Using suitable spark plug cleaning tool, clean spark plugs & inspect for cracked, burned or blistered insulators.



Bend side electrode only when adjusting gap.

Avoid over tightening when installing.

Check point gap with round gage of the recommended gap thickness.

If recommended torque is not known, tighten finger tight, then tighten approximately 1/3 turn with wrench.

IGNITION WIRE-VISUAL INSPECTION

Inspect all ignition wires for frayed, broken or oil soaked insulation; poor bond between wire & terminals; loose terminal nuts. Inspect distributor & coil towers for cracks. Be sure spark plug wires are firmly seated in towers.

TUNE-UP

DISTRIBUTOR

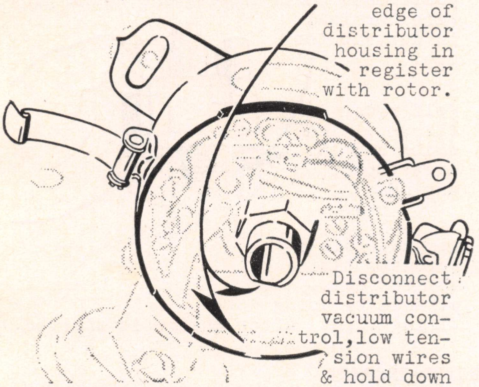
Often the distributor is located where a thorough inspection is difficult without removal.

For this reason it is good practice to remove distributor from engine for inspection & adjustment.

DISTRIBUTOR-INSPECT

Before removing distributor rotate the crankshaft until number one piston is top center of firing stroke.

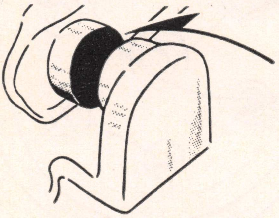
Remove distributor head. Place mark on edge of distributor housing in register with rotor.



Disconnect distributor vacuum control, low tension wires & hold down screw. Remove distributor from engine.

CAUTION- Avoid moving crankshaft while distributor is removed from engine.

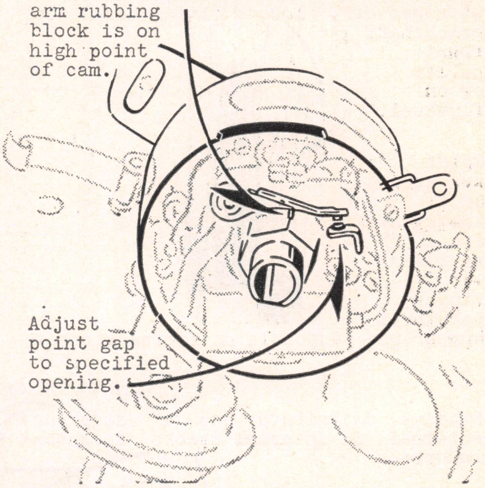
Separate contact points, inspect faces.



Faces should be smooth, showing contact across full width of faces.

Replace contact points showing burned or uneven contact surfaces.

Rotate distributor shaft until breaker arm rubbing block is on high point of cam.



Adjust point gap to specified opening.

Disconnect the vacuum control arm at breaker plate. With cam positioned so contact points are open, move contact arm pivot pin back & forth toward the point arm rubbing block. If point gap is altered more than .005", replace breaker plate assembly.

Inspect distributor shaft & drive gear or coupling, for worn or damaged parts.

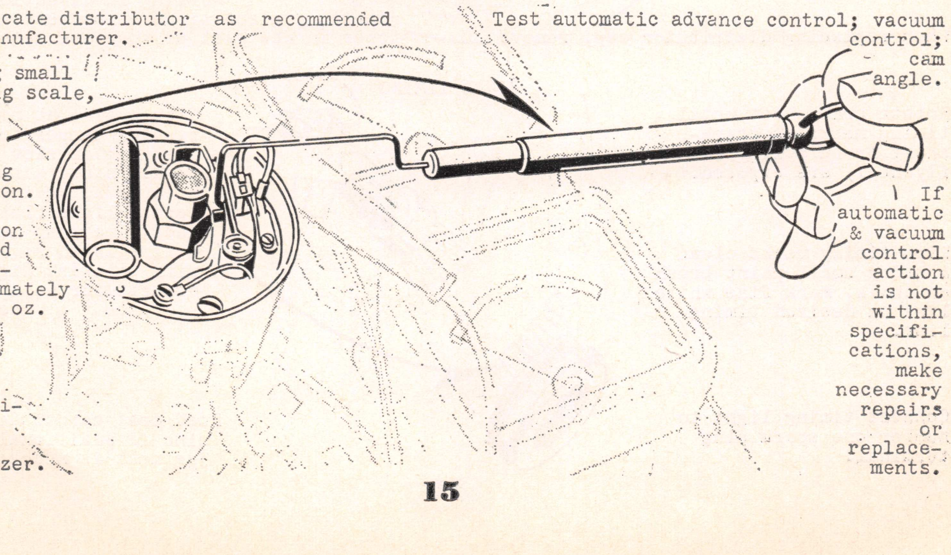
DISTRIBUTOR-TEST

Lubricate distributor as recommended by manufacturer.

Using small spring scale, test point arm spring tension.

Tension should be approximately 17-21 oz.

Place distributor on analyzer.



Test automatic advance control; vacuum control; cam angle.

If automatic & vacuum control action is not within specifications, make necessary repairs or replacements.

TUNE-UP

DISTRIBUTOR-INSTALL

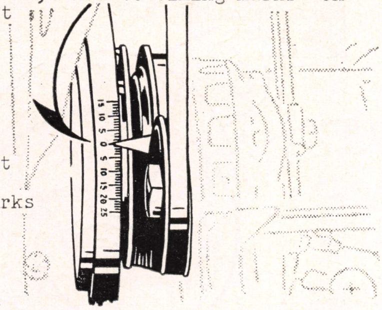
Approximate correct ignition timing must be established when distributor is placed on engine.

If crankshaft has not been moved while distributor was off engine, rotate distributor shaft until rotor is in register with mark previously made on the edge of housing. Holding rotor in this position, set distributor in place.

Install hold down bolt. Connect low voltage wire & vacuum tube.

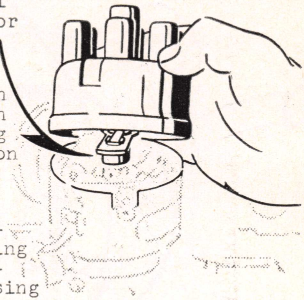
INITIAL TIMING

If crankshaft was moved while distributor was off, locate timing marks on crankshaft front pulley or on flywheel.



Rotate crankshaft until timing marks are in register with timing pointer & number one piston is on firing stroke.

Rotate distributor shaft so rotor is positioned under number one spark plug wire terminal in distributor cap.

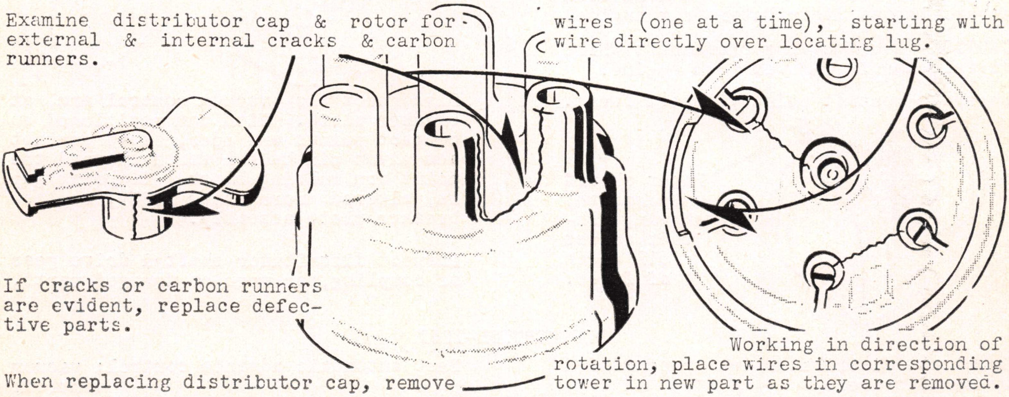


Hold rotor in this position while setting distributor on engine.

Accurate distributor timing may be accomplished by using timing light after engine is started.

DISTRIBUTOR CAP & ROTOR-INSPECT

Examine distributor cap & rotor for external & internal cracks & carbon runners.



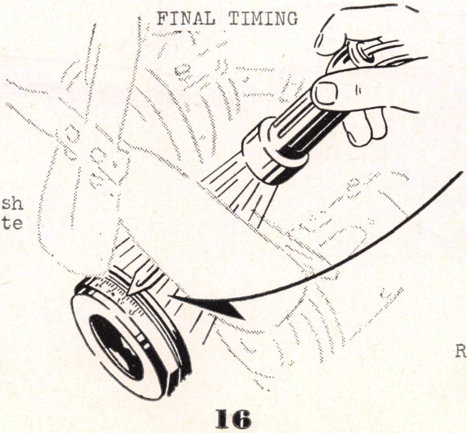
If cracks or carbon runners are evident, replace defective parts.

When replacing distributor cap, remove wires (one at a time), starting with wire directly over locating lug.

Working in direction of rotation, place wires in corresponding tower in new part as they are removed.

FINAL TIMING

Rotate crankshaft until timing marks on crankshaft front pulley (or flywheel) are exposed.



Wipe timing marks clean & using small paint brush or chalk, mark fine white line on desired timing line.

Connect timing light to number one spark plug terminal.

With engine at normal running temperature & running at slow idle speed, rotate distributor as desired to cause light flash at exact time when marked line is in register with pointer. Tighten distributor hold down screw.

Road test car to determine if additional adjustment is necessary.

TUNE-UP

FUEL SYSTEM

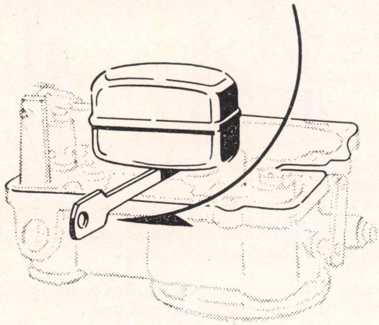
Carburetors of two types are most commonly used. DOWNDRAFT type, mounted above the inlet manifold; UPDRAFT type, mounted below the inlet manifold.

Both types are divided into five systems; float, idle, main metering, power & accelerating. When reconditioning, follow manufacturers recommendations.

CARBURETOR-INSPECT

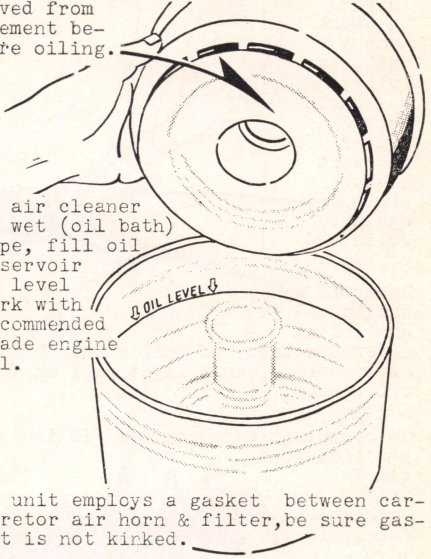
If carburetor is to be used without reconditioning, remove air cleaner & float cover.

Measure height of float, or fuel level, as recommended by manufacturer.



When adjustment is necessary, bend lip that contacts needle valve to raise or lower float to obtain specified setting.

Clean & reoil the air cleaner element. Be certain all cleaning solvent is removed from element before oiling.

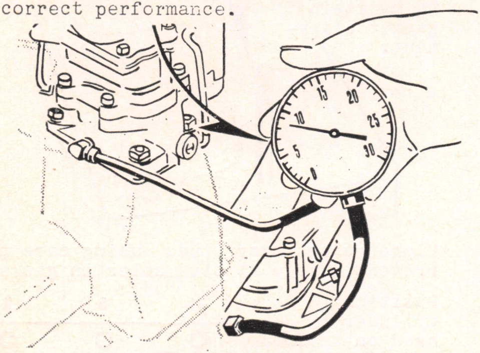


If air cleaner is wet (oil bath) type, fill oil reservoir to level mark with recommended grade engine oil.

If unit employs a gasket between carburetor air horn & filter, be sure gasket is not kinked.

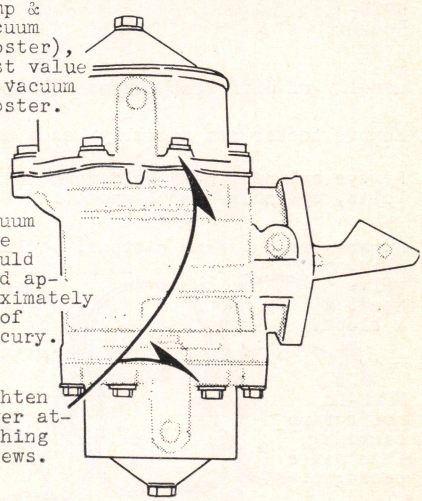
FUEL PUMP-TEST

Test fuel pump input & output. Recondition pump if necessary to obtain correct performance.



Be certain flexible section of fuel line has not collapsed or does not leak. If flexible line is soft or mushy when compressed between thumb & finger, install new one.

If fuel pump is combination type (fuel pump & vacuum booster), test value of vacuum booster.



Vacuum gage should read approximately 9" of mercury.

Tighten cover attaching screws.

MANIFOLDS-INSPECT

Visually inspect the intake & exhaust manifolds for cracks, broken or missing attaching bolts & blown-out gaskets.

Tighten manifold attaching bolts to specified torque tension. Replace broken or blown-out gaskets.

CYLINDER HEAD ASSEMBLIES

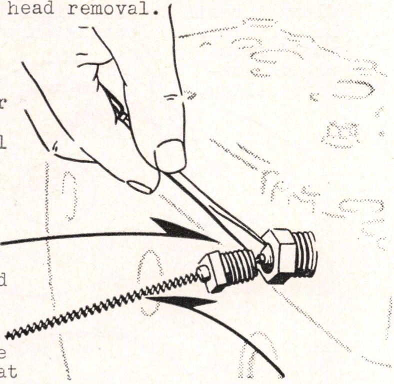
CYLINDER HEAD GASKET-REPLACE

WATER-REMOVE

IMPORTANT- Drain only sufficient water to allow cylinder head removal. This will leave radiator approximately 1/2 filled, preventing hardening of rust & sediment & resultant excessive engine heat.

CYLINDER HEAD-REMOVE-INSTALL

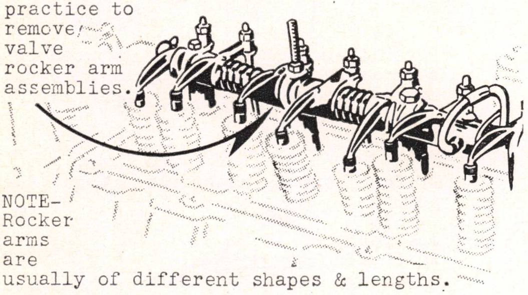
Remove accessories (air cleaner, throttle linkage etc.) as needed to allow cylinder head removal.



To free up stuck heat indicator bulbs, use small screw driver to exert light pressure against solid end of bulb.

Pressure should be applied at several points of bulb circumference, at same time exert light pull on indicator tube.

On overhead type engines it is good practice to remove valve rocker arm assemblies.

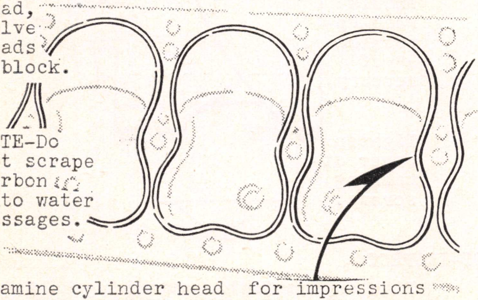


NOTE- Rocker arms are usually of different shapes & lengths.

Remove rocker arm assembly as a unit.

Remove cylinder head hold-down nuts or bolts, cylinder head & gasket.

Scrape carbon from pistons, cylinder head, valve heads & block.

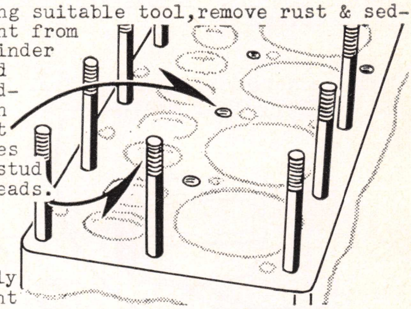


NOTE-Do not scrape carbon into water passages.

Examine cylinder head for impressions caused by gasket. Resurface if necessary.

Remove rust, wire or other foreign matter from water passages in cylinder head & block.

Using suitable tool, remove rust & sediment from cylinder head hold-down bolt holes or stud threads.



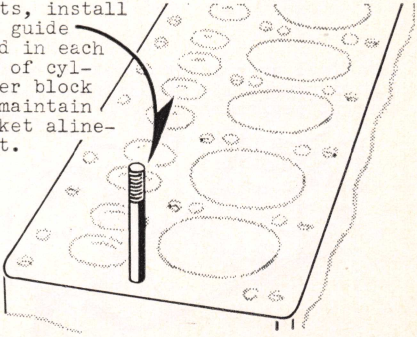
Apply light coat of lubricating oil to threads.

Wipe carbon dust from tops of pistons, cylinder bores & valves.

Apply light coat of lubricating oil to tops of cylinders & valves.

Before placing gasket on the cylinder block be certain all carbon & rust flakes are removed from cylinder head & block gasket surfaces.

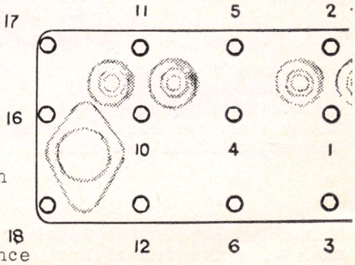
INSTALL: On engines employing hold-down bolts, install one guide stud in each end of cylinder block to maintain gasket alinement.



Place gasket over studs using care to prevent damage at stud holes in gasket

Position cylinder head on block.

Using tension wrench, tighten hold-down bolts or nuts evenly & in sequence as recommended by engine manufacturer.



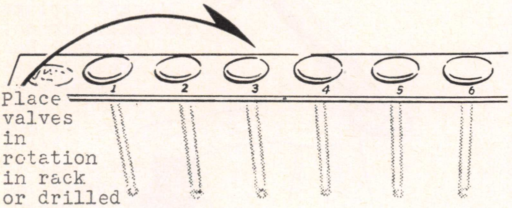
VALVE ASSEMBLIES

Worn valve stems & guides allow oil vapors to be drawn into the intake manifold & combustion chambers contributing to high oil consumption.

VALVE-INSPECTION

Remove cylinder head as outlined in (CYLINDER HEAD GASKET - REMOVE & INSTALL).

Using suitable valve spring compressor, remove valve locks & valves.

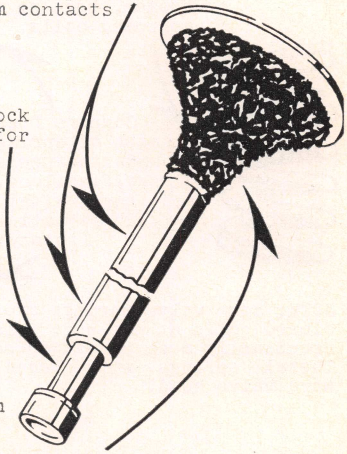


Place valves in rotation in rack or drilled stick so they will be reinstalled in their original guides.

Using wire buffer wheel or suitable tool, clean valve heads & stems. Inspect valves for wear & other defects.

Return valves to their respective positions in rack after inspection.

Worn valve stems are indicated by highly polished stems; noticeable shoulders at top & bottom where stem contacts guide.



Inspect lock recesses for wear.

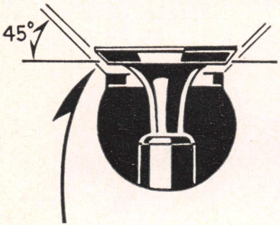
Excessive carbon deposited under valve head indicates excessive valve stem to guide clearance or defective vacuum booster diaphragm.

Replace valves with worn or bent stems, thin or burnt heads or worn lock recesses.

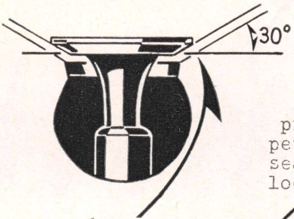
VALVES-RECONDITION

Valve face angle will vary with manufacturers specifications. Intake valve & exhaust valve face angles are often different in same engine.

Determine valve face angle. Set valve refacing equipment to desired angle & dress facing stone with diamond dressing tool.



45° face angle

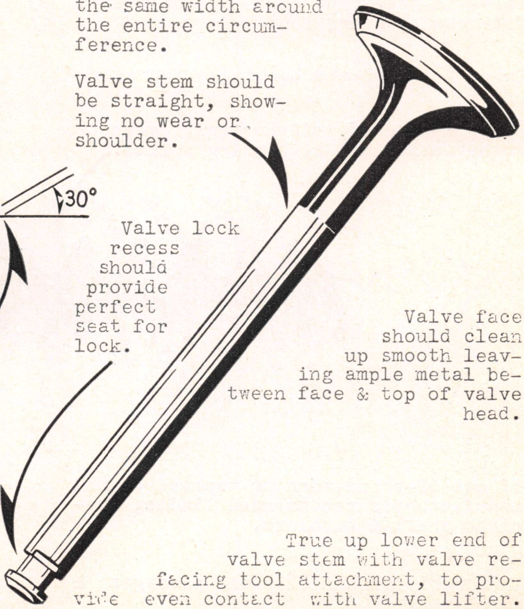


30° face angle

NOTE- Some manufacturers recommend the valve face angle be 1° less than the seat angle. Example- Seat angle, 45°; valve face angle, 44°.

This creates an "Interference Angle", & insures seating when some valve or seat distortion exists. Not recommended when valve rotators are used.

The desired reconditioned valve face will be smooth & approximately the same width around the entire circumference.



Valve stem should be straight, showing no wear or shoulder.

Valve lock recess should provide perfect seat for lock.

Valve face should clean up smooth leaving ample metal between face & top of valve head.

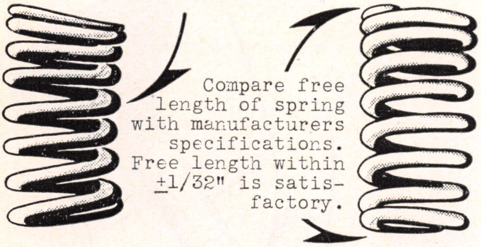
True up lower end of valve stem with valve refacing tool attachment, to provide even contact with valve lifter.

VALVE ASSEMBLIES

VALVE SPRINGS

Weak, bent or broken valve springs will interrupt compression pressures, resulting in uneven engine operation & high oil consumption.

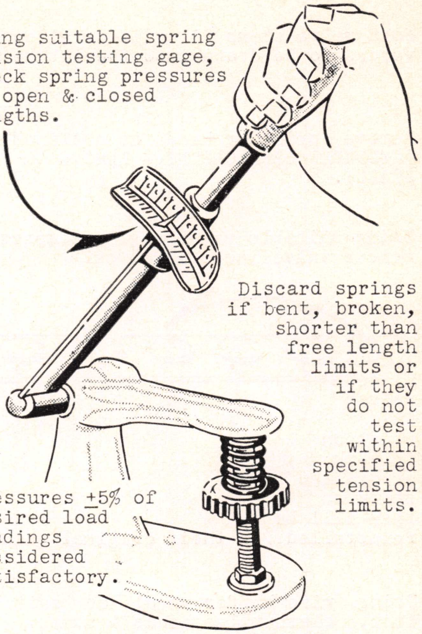
Remove valve springs & inspect each spring for set, broken, bent or corroded coils.



Compare free length of spring with manufacturers specifications. Free length within ±1/32" is satisfactory.

NOTE: Some valve springs are made with closed coils at one end. This does not necessarily mean a weak or set spring. Install springs with closed coils toward valve head.

Using suitable spring tension testing gage, check spring pressures at open & closed lengths.



Discard springs if bent, broken, shorter than free length limits or if they do not test within specified tension limits.

Pressures ±5% of desired load readings considered satisfactory.

VALVE ADJUSTING SCREWS

Pitted & uneven valve adjusting screws make proper valve clearance adjustment impossible. Inspect screw surfaces for wear.

Slightly pitted surfaces may be refaced on valve refacing tool. If pitted more than .005", or if previously refaced, use new screws.

ROCKER ARM ASSEMBLY-INSPECT

Inspect rocker arm assemblies, used on valve-in-head type engines, for wear & freeness of operation.

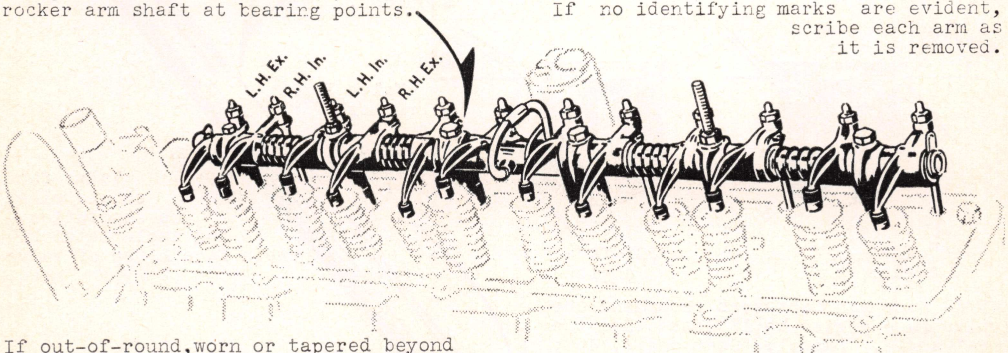
Inspect rocker arm bushings for wear.

Using standard micrometers, measure rocker arm shaft at bearing points.

NOTE-The intake & exhaust valve rocker arms are not always interchangeable.

Locate identifying marks on the rocker arms to identify their positions.

If no identifying marks are evident, scribe each arm as it is removed.


L.H. Ex.
R.H. In.
L.H. In.
R.H. Ex.

If out-of-round, worn or tapered beyond manufacturers recommended limits, replace shaft & bushings.

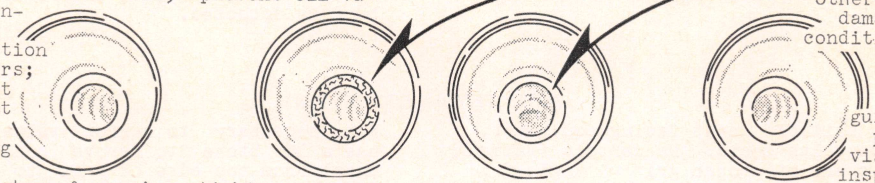
Thoroughly clean all oil passages & oil lines.

Replace arms that show excessive wear at valve stem contact end. Be certain adjusting screws are free in threads of rocker arms.

VALVE ASSEMBLIES

VALVE GUIDES-VISUAL INSPECTION

Valve guide fit to valve stem must be within specified limits to accurately return valve to seat; prevent oil vapors entering combustion chambers; prevent exhaust vapors blowing down valve stems & causing sticking valves.



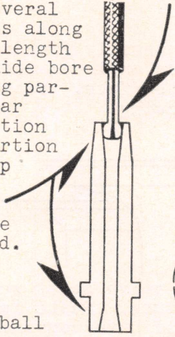
Visually inspect upper ends of guides for cracks, oblong holes, burned or otherwise damaged condition.

If guides pass visual inspection, proceed with wear inspection.

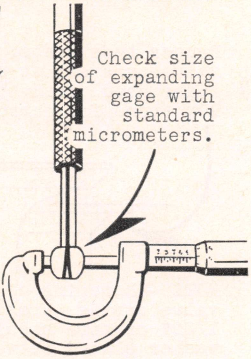
VALVE GUIDE-WEAR INSPECTION

Clean inside surface of guides with suitable cleaning tool.

Using expanding ball type gage, measure bore of valve guides. Make measurements at several points along full length of guide bore paying particular attention to portion at top where guide may be belled.



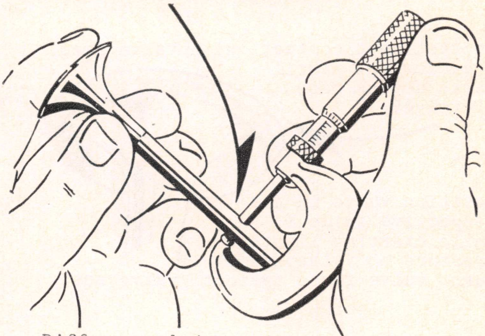
Check size of expanding gage with standard micrometers.



When ball type gage is not available, insert a solid pilot that will fit the guide bore snug at about 3/4 depth. Pencil mark pilot at top of guide.

Remove pilot & recheck size with micrometers.

Then measure valve stem.

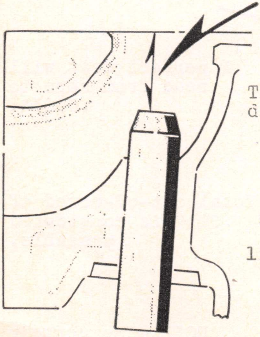


Difference between the two measurements represents stem to guide clearance.

If clearance is more than recommended limits, install new guide.

VALVE GUIDES-INSTALL

Before pressing old guides from cylinder head, or block, measure distance from top of guide to machined surface of head or block.

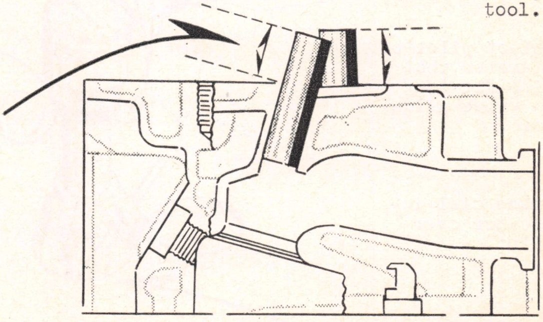


This distance may differ with inlet & exhaust valve guides.

On "L" head engines be certain valve springs & lifter screws are cleared.

Before pressing new guides into place, be certain they match old ones in every detail.

Press new guides into position as previously measured, then check for possible cracks at top of guides caused by installing tool.



Ream bore of guide to remove any burrs caused by installing tool.

VALVE ASSEMBLIES

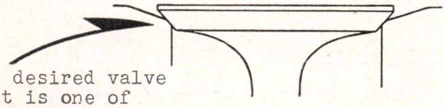
VALVE SEATS-INSPECT

Valve seats must be smooth, even & of specified width.
Visually inspect the valve seats for cracks.

If seats are insert type, inspect for loose bond between insert & cylinder head or block. Replace insert if loose bond is detected.

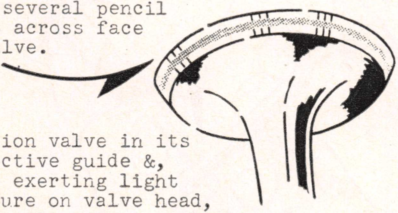
VALVE SEATS-RECONDITION

Using suitable seat facing equipment, reface valve seats. Be certain facing stones are of proper grit & angle for seats.



The desired valve seat is one of specified width that contacts valve face to within 1/64" of outer edge of valve face.

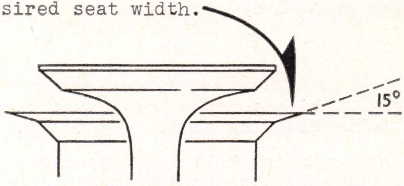
To test seat contact with valve face, draw several pencil marks across face of valve.



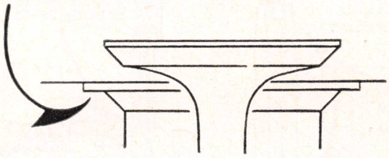
Position valve in its respective guide &, while exerting light pressure on valve head, turn valve face against valve seat.

Broken pencil marks indicate valve face to seat contact.

When necessary to narrow valve seat, use a 15° stone to remove sufficient metal from top edge of seat to obtain desired seat width.



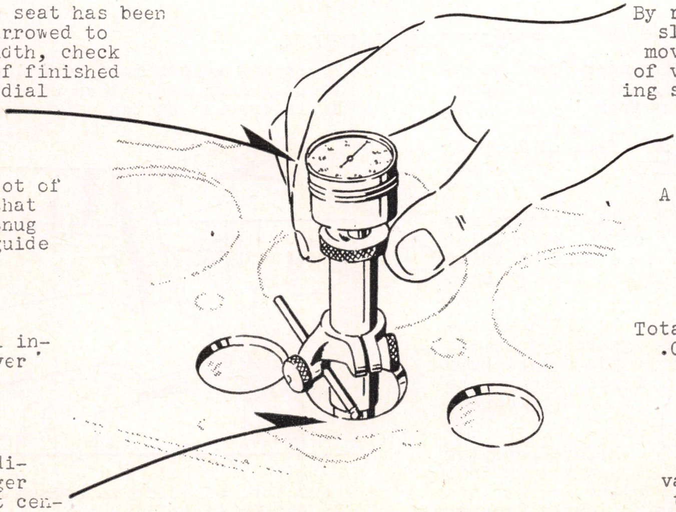
Recess type seats, usually found where valves are set at an angle to the cylinder head gasket surface, require a 90° stone for narrowing.



NOTE - Lowering of valve seat weakens valve spring pressure. Seats lowered 1/32" or more should have compensating washer placed between end of spring & cylinder block.

VALVE SEATS-CHECK

When valve seat has been faced & narrowed to uniform width, check trueness of finished seat with dial indicator.



Select pilot of diameter that will fit snug in valve guide bore.

Place dial indicator over pilot.

Adjust indicator finger to contact center of valve seat & set dial at zero.

By rotating indicator slowly, dial finger moves around surface of valve seat recording surface variations on dial.

A perfect seat will read from zero to .0005".

Total out-of-round of .001" is considered passable.

NOTE - Be certain valve seat has been thoroughly cleaned before trueness test is performed.

VALVE ASSEMBLIES

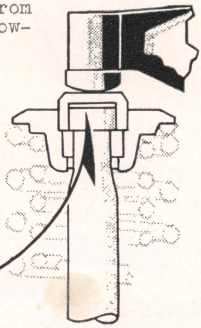
ROTO TYPE VALVE MECHANISM

Some engines employ "ROTO TYPE" mechanism in connection with valve springs. This mechanism allows, or causes, valve rotation while the valve is open.

This action eliminates localized hot spots; build-up of deposits between valve face & seat; build-up of deposits between valve stem & guide.

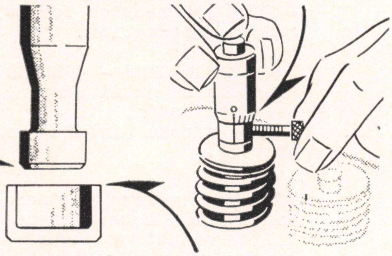
ROTO MECHANISM-INSPECT

RELEASE TYPE: When valve is open, spring pressure is released from end of valve stem, allowing valve to rotate because of engine vibration.



Efficiency of "RELEASE TYPE" roto mechanism is largely dependent on tip cup to valve stem clearance which should be set at, or near, low limits at time of installation.

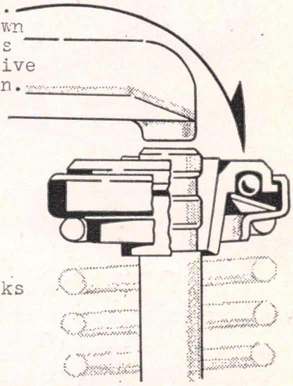
Special gage is necessary to check the valve stem to tip cup clearance.



To increase clearance, grind off end of valve stem.

To decrease clearance, grind off end of cup.

POSITIVE ROTATION TYPE: As valve starts to open "belville" washer flexes. Balls roll down inclined races causing positive valve rotation.



Clean parts thoroughly.

Examine parts for wear, nicks or burrs.

NOTE- When replacing conventional type valve spring cap with positive rotator type valve spring cap it is some times necessary to use different valve or spring. Follow instructions furnished with roto mechanism.

Valve clearance adjustment is accomplished in conventional manner.

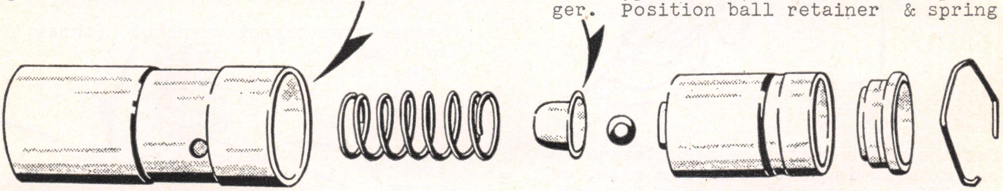
VALVE LIFTERS-HYDRAULIC

It is good practice to remove all hydraulic valve lifters for inspection when valves are reconditioned.

Hydraulic valve lifters are very carefully matched & must be reinstalled in same bores from which they are removed.

DISASSEMBLE

While holding down on push rod cup, use pointed tool to remove wire lock.



Invert lifter & slide out push rod cup, plunger, ball retainer & spring.

NOTE-Stuck plungers can often be loosened by soaking unit in clean solvent.

Thoroughly clean all parts in clean solvent.

ASSEMBLE

While holding plunger in inverted position, place ball on its seat in plunger. Position ball retainer & spring over ball. Lower lifter body over plunger assembly.

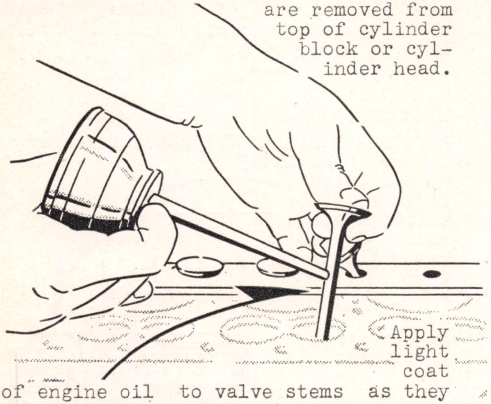
Turn the assembly right side up & fill with clean engine oil.

Use small wire to unseat ball until oil is drained from plunger to lifter body. Refill plunger with oil. Install push rod cap & lock wire.

VALVE ASSEMBLIES

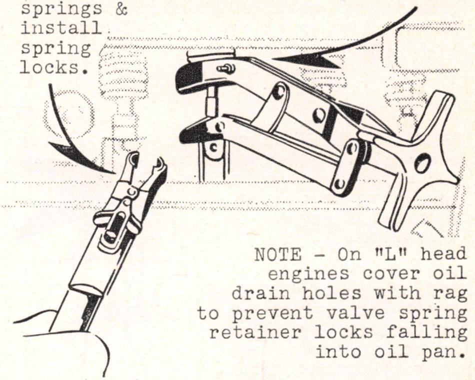
VALVES-INSTALL

Be certain all dirt, oil & abrasives are removed from top of cylinder block or cylinder head.



Apply light coat of engine oil to valve stems as they are placed in guides.

Using suitable tools, compress valve springs & install spring locks.



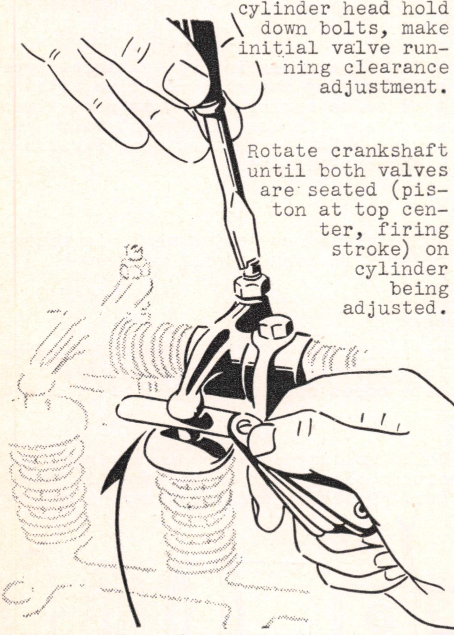
NOTE - On "L" head engines cover oil drain holes with rag to prevent valve spring retainer locks falling into oil pan.

Install cylinder head as outlined in "CYLINDER HEAD GASKET-REMOVE-INSTALL".

VALVE RUNNING CLEARANCE-ADJUST

VALVE-IN-HEAD ENGINE: After tightening cylinder head hold down bolts, make initial valve running clearance adjustment.

Rotate crankshaft until both valves are seated (piston at top center, firing stroke) on cylinder being adjusted.



Set the valve clearance adjustments so slight drag is felt as feeler gage, of specified running clearance thickness, is passed between end of valve stems & end of rocker arms.

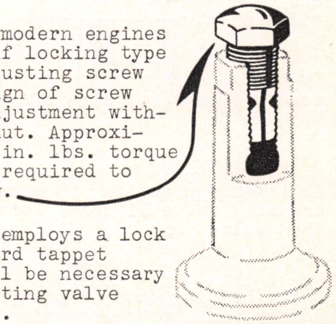
Lock adjustments in this position. Repeat operation on all valves, being sure piston is at top center, firing stroke.

NOTE - Always recheck valve clearance adjustments after tightening cylinder head bolts.

HYDRAULIC VALVE TAPPET: Consult "REPAIR & TUNE-UP" section for adjustment procedure information.

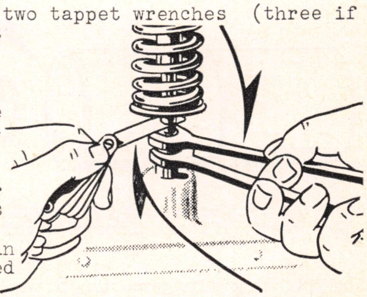
"L" HEAD ENGINE - COLD ENGINE: Rotate crankshaft until piston, on cylinder being adjusted, is at top center of firing stroke (intake & exhaust valves seated).

NOTE-Most modern engines employ self locking type lifter adjusting screw where design of screw secures adjustment without lock nut. Approximately 25 in. lbs. torque should be required to turn screw.



If tappet employs a lock nut, a third tappet wrench will be necessary when adjusting valve clearances.

Secure two tappet wrenches (three if lock nut type). Holding tappet with one wrench, turn screw, right or left, as needed to obtain specified running clearance as measured with feeler gage.



Final clearance test & adjustment is made after engine is run & heated to normal operating temperature.

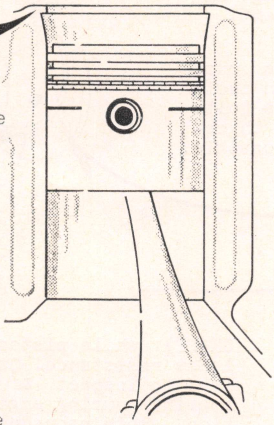
PISTON & CONNECTING ROD ASSEMBLIES

If preliminary tests indicated major engine overhaul is necessary, remove cylinder head & recondition valves as outlined in "VALVES-RECONDITION".

CYLINDER RIDGE-REMOVE

Cylinder ridge, is shoulder of metal formed at upper end of ring travel, & must be removed before piston assemblies are withdrawn from cylinders.

Piston assemblies forced out of, or into, cylinders that are ridged will result in broken piston rings or broken ring lands.

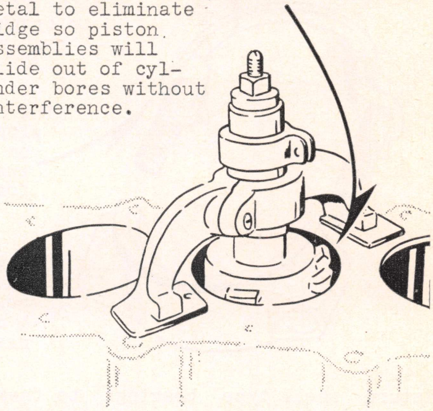


To remove cylinder ridge, allow engine block to cool.

Clean carbon from top of pistons & cylinder block.

Using standard ridge cutting tool, set tool blade to register with ridge to be removed.

Adjust cutter to take light cut. Taking repeated light cuts, remove only enough metal to eliminate ridge so piston assemblies will slide out of cylinder bores without interference.



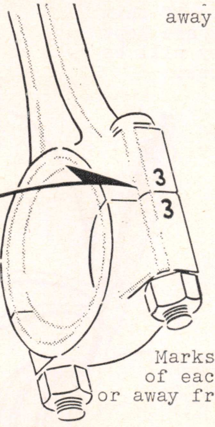
Metal cuttings will be removed from cylinders, when piston assemblies are withdrawn.

NOTE - On some engines the pistons are removed from the bottom. In this case cover crankshaft journals & main bearing oil holes with cloth before removing cylinder ridge.

CONNECTING ROD & PISTON ASSEMBLIES-IDENTIFY

Connecting rod & piston assemblies must be reinstalled in their original cylinders & in same relative positions. This is particularly true when lower end of connecting rod is off-set.

NOTE-Short side of off-set is usually faced toward nearest main bearing.



Identifying numbers, stamped on portion of connecting rod & cap, where bolt passes through, are for the purpose of associating the assembly with its individual cylinder, & position it must assume in cylinder.

It is important to note which side of engine the numerals face (toward or away from camshaft) so they will be assembled in that order.

On some reconditioned rods, identifying marks or numbers may not be correct or may be missing. If no marks are evident or marks are not numerically similar, use center punch or number die to mark cap & shank of rod according to cylinder in which it has been operating.

Marks must be placed on same side of each rod & cap (facing camshaft or away from camshaft side of engine).

Connecting rod caps must be installed on the connecting rods so numbers are alined.

PISTON & CONNECTING ROD ASSEMBLIES

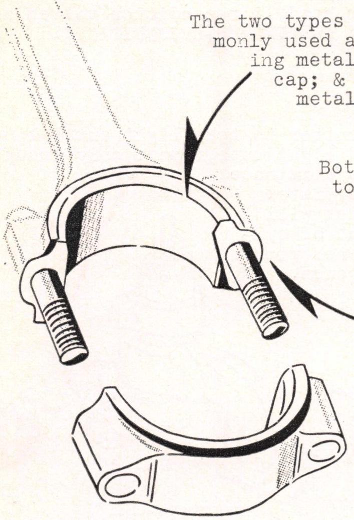
CONNECTING ROD BEARINGS-IDENTIFY

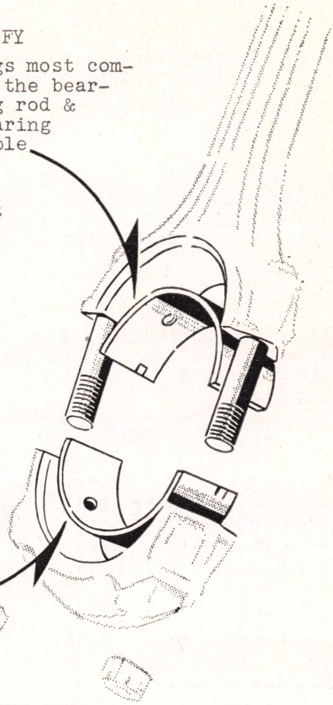
The two types of connecting rod bearings most commonly used are integral type, where the bearing metal is bonded to connecting rod & cap; & "INSERT" type, where bearing metal is bonded to a replaceable shell.

Both types are precision fit to crankshaft journal size requiring no further fitting.

The assembly may employ a shim pack, on each side between rod & cap, for bearing adjustment.

Shim packs must be kept on their respective bolts & of even thickness if possible.





Return shell type bearings to their respective rods & caps, as assemblies are removed, for further inspection.

At this point of disassembly, there are two schools of thought prevailing. Some mechanics prefer to inspect crankshaft journals, test bearing fit to journal, & replace necessary parts (outlined in CONNECTING ROD BEARING FIT TO CRANKSHAFT) while piston assemblies offer least resistance. Other mechanics prefer to inspect & fit connecting rod bearings during engine assembly operation. Both procedures have their advantages & disadvantages.

CONNECTING ROD & PISTON ASSEMBLIES-REMOVE

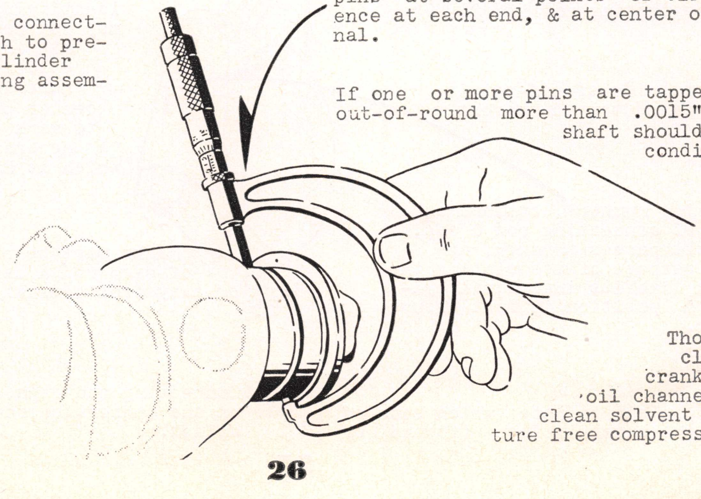
Remove connecting rod caps. If shim packs are used, be sure they are kept in packs, as removed, so they will be returned to their proper places.

Wrap lower ends of connecting rods with cloth to prevent scratching cylinder walls while removing assemblies.

Install caps on rods, with cap number & rod number alined, for further inspection.

Crank pin surfaces must be smooth & round, within .0015".

Slightly rough crank pins may be smoothed by polishing with crocus cloth.



Using standard micrometers, measure pins at several points of circumference at each end, & at center of journal.

If one or more pins are tappered or out-of-round more than .0015" crankshaft should be reconditioned.

Thoroughly clean all crank pins & oil channels with clean solvent & moisture free compressed air.

CAMSHAFT DRIVE ASSEMBLY

CAMSHAFT LASH-INSPECT

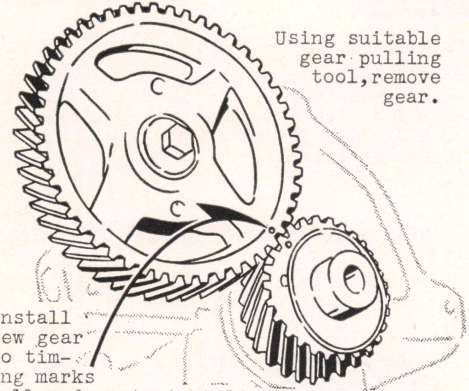
Excessive camshaft lash causes uneven valve & distributor timing at some engine speeds, resulting in high cylinder pressures & oil pumping.

By rocking crankshaft & watching camshaft movement, amount of lash may be determined. If lash is in excess of specified limits, a new camshaft gear or chain should be installed.

Accurate camshaft timing must be maintained when making replacement.

CAMSHAFT GEAR OR CHAIN-INSTALL

Extreme care must be used when removing & installing camshaft gears. To pry gear from shaft or to hammer gear onto shaft may result in damaged camshaft bearings, damaged tappets or serious oil leak at expansion plug at the rear camshaft bearing.



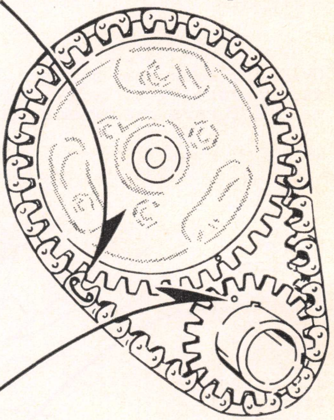
Using suitable gear pulling tool, remove gear.

Install new gear so timing marks fall under straight line drawn through shaft centers.

Be certain gear lubrication tube is clear.

Timing chain may or may not employ a detachable link to facilitate removal & installation.

If chain does not employ a detachable link, it will be necessary to remove cam sprocket to make chain replacement.



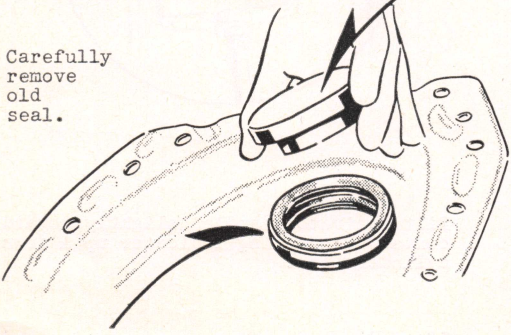
Install timing chain so timing marks on sprockets are in register with marked chain links, or fall under line through shaft centers as specified by engine manufacturers.

Check chain lubrication system.

GEAR OR CHAIN COVER-INSTALL

Remove all traces of old gasket from surface of cover. Be certain gasket surface is true. Straighten surface face around bolt holes if necessary.

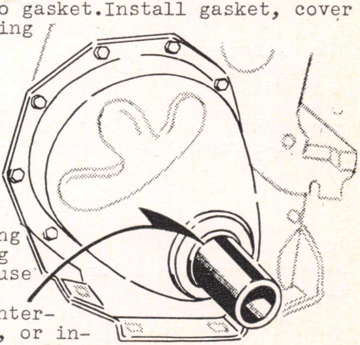
Carefully remove old seal.



Thoroughly clean seal recess. Position new seal, & gasket if used, in recess with free edge of seal inward.

Using suitable driver or arbor, press seal into recess.

Apply coat of heavy grease or gasket cement to gasket. Install gasket, cover & attaching screws.



Before tightening attaching screws, use suitable cover centering tool, or install fan pulley to aline oil seal with crankshaft.

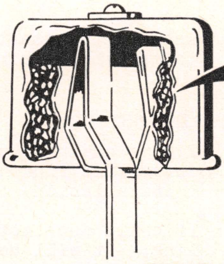
Tighten the cover screws to specified torque tension.

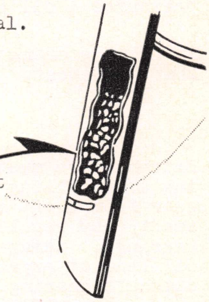
CRANKCASE VENTILATION

CRANKCASE VENTILATION-INSPECT

Crankcase ventilation removes harmful acids & moisture from the crankcase by means of air circulation.

Clogged oil filler pipe breather cap, or vent pipe element, will prevent air circulation through the engine resulting in oil dilution, & in extreme cases, high crankcase pressures, resulting in oil leaks at piston rings, front main bearing seal & rear main bearing seal.





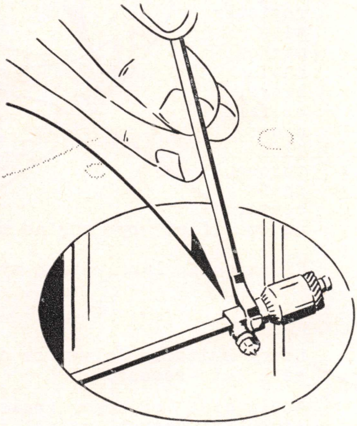
Clean breather cap & vent pipe elements with cleaning solvent or suitable cleaning agent.

CYLINDERS

CYLINDER BORE-INSPECT

Cylinder bore wear & taper limits will vary according to bore size & engine manufacturers recommendations.

Using standard inside micrometers, measure cylinder bore diameters at several points around circumference, near top of each cylinder.



The difference in highest & lowest measurements represents out-of-round.

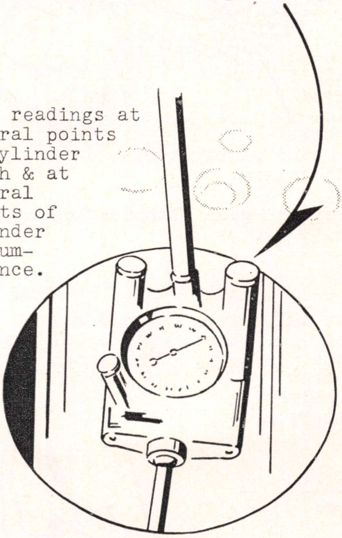
Repeat operation below point of piston ring travel.

Difference between largest measurement at top of cylinder & smallest reading at bottom of cylinder represents cylinder taper.

When using dial indicator to check the cylinder walls, be certain indicator skids are flat against cylinder wall & dial anvil is seated square against opposite wall.

Move indicator full length of cylinder

Take readings at several points of cylinder depth & at several points of cylinder circumference.



Tilt indicator handle slightly toward center when moving indicator up & down cylinder bore.

If readings show taper or out-of-round in excess of specified limits, recondition cylinder bores.

CYLINDERS

CYLINDER WALL GLAZE

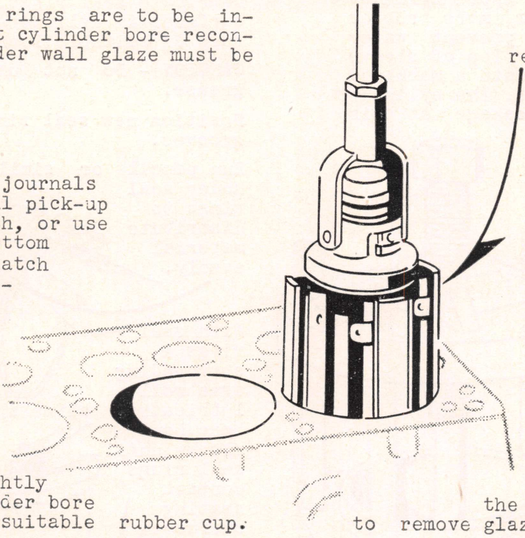
Cylinder wall glaze, the smooth hard surface of worn cylinder walls, will prevent normal piston ring "BREAK-IN".

The result is usually "BLOW-BY", oil dilution, engine heating &, in extreme cases, collapsed pistons.

CYLINDER WALL GLAZE-REMOVE

When new piston rings are to be installed, without cylinder bore reconditioning, cylinder wall glaze must be removed.

Using cylinder hone or suitable cylinder glaze removing tool, take light cuts along full length of cylinder bore until glaze is removed.



Cover crankshaft journals & main bearing oil pick-up troughs with cloth, or use rubber cups at bottom of cylinders to catch abrasives when removing cylinder glaze.

NOTE - Use extreme care to prevent touching rubber cups, or cloth crankshaft covers, with hone when cleaning bottom of cylinders.

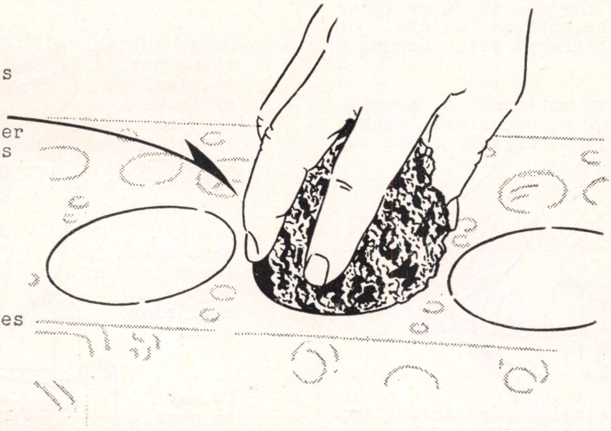
A half of hollow rubber ball, slightly larger than cylinder bore diameter, makes suitable rubber cup.

Just a few strokes of the hone should be required to remove glaze from cylinder walls.

CYLINDER WALLS-CLEAN

Before removing crankshaft cover cloth or rubber cups, clean abrasives from cylinder walls.

Avoid direct stream of water or other method of cleaning that will wash abrasives into pores of metal.



Wash cylinder walls with warm soapy water & sponge, or use suitable cleaner to remove abrasives from pores of wall metal.

NOTE-Apply light coat of lubricating oil to cylinder wall surfaces immediately after cleaning.

Warm soapy water will float abrasives out of pores.

Gasoline & most solvents tend to wash abrasives into pores of metal where they later find their way into the lubricating oil, causing excessive engine parts wear.

When cylinder walls are cleaned & oiled, carefully remove rubber cups or cloth from crankshaft & main bearing oil troughs. Avoid spilling abrasives when removing protectors.

CYLINDERS

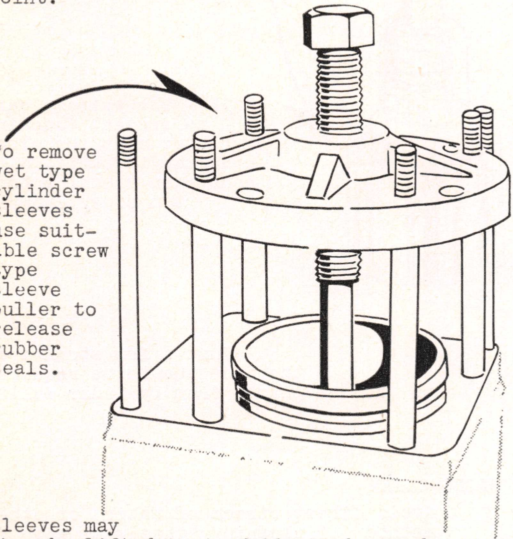
CYLINDER SLEEVES

Replaceable cylinder sleeves are often used by the engine manufacturers. When worn, sleeves may be replaced rather than reconditioned.

Cylinder sleeves are of two types. (1) "Wet Type" which is exposed to water used for cooling. (2) "Dry Type" which is not exposed to the water.

CYLINDER SLEEVES-REMOVE-INSTALL

WET TYPE - REMOVE: Wet type cylinder sleeves employ two or more rubber seals at lower end to prevent water leakage into crankcase. Top of sleeve has a flange that fits into a machined recess in cylinder block. The cylinder head gasket prevents leakage at this point.

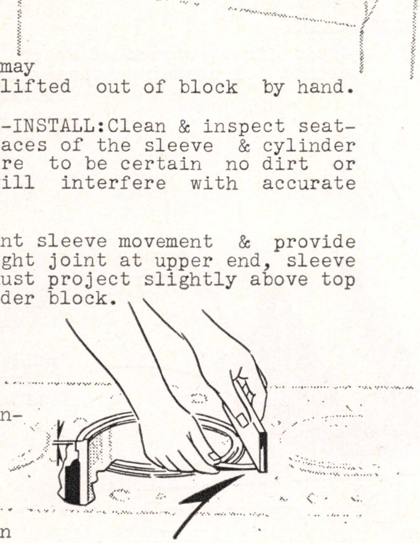


To remove wet type cylinder sleeves use suitable screw type sleeve puller to release rubber seals.

Sleeves may then be lifted out of block by hand.

WET TYPE-INSTALL: Clean & inspect seating surfaces of the sleeve & cylinder block bore to be certain no dirt or burrs will interfere with accurate seating.

To prevent sleeve movement & provide water tight joint at upper end, sleeve flange must project slightly above top of cylinder block.



Place sleeve, less rubber rings, into bore.

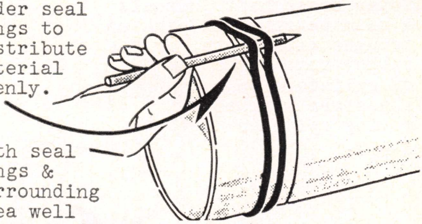
With sleeve flange seated in recess, place straightedge across top of flange. Measure distance between straightedge & top of block with feeler gage.

This measurement (crush) must be within manufacturers specified limits.

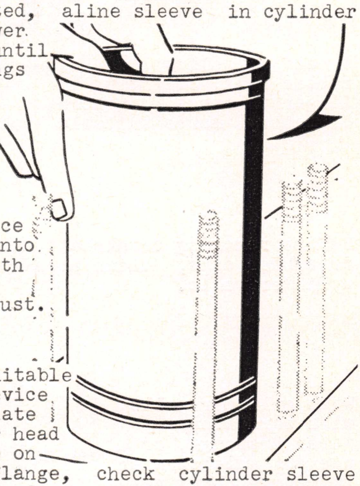
Lubricate seal rings, grooves & seating surfaces in cylinder bore with liquid soap or suitable lubricant.

CAUTION - Do not use engine oil or grease.

Position new seal rings in the sleeve grooves.



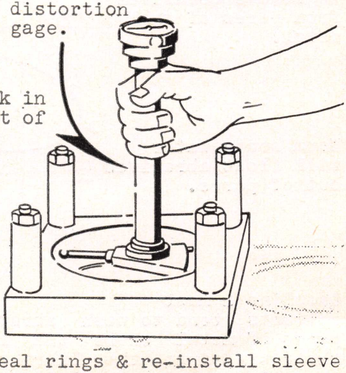
Run pencil or similar device around under seal rings to distribute material evenly.



With seal rings & surrounding area well lubricated, aline sleeve in cylinder bore. Lower sleeve until seal rings contact seating surface.

Then force sleeve into place with a smart, firm thrust.

Using suitable clamp device to simulate cylinder head pressure on sleeve flange, check cylinder sleeve bores for distortion with dial gage.

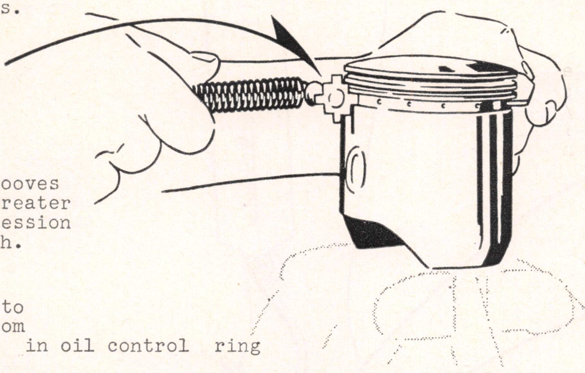


Make check in lower part of sleeve in seal ring area.

It may be necessary to remove sleeve, relubricate seal rings & re-install sleeve to obtain satisfactory gage reading.

PISTON ASSEMBLIES

PISTONS-INSPECT



Remove piston rings from pistons,& using suitable ring groove cleaner, clean carbon from ring grooves.

Select cutter of proper width for groove.

NOTE-Oil ring grooves are usually of greater width than compression ring groove width.

Use small drill to remove carbon from oil drain holes in oil control ring grooves.

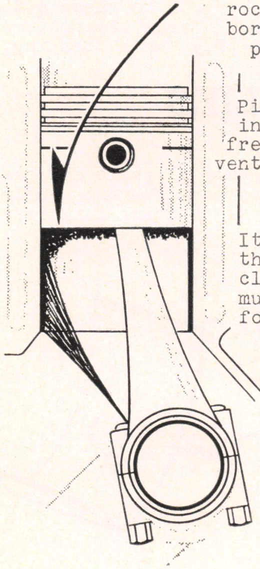
Clean carbon from top of pistons. Wash pistons in cleaning solvent or suitable cleaning agent & inspect for broken or worn ring lands, cracked skirts, scored surfaces or other damage.

NOTE - The most minute crack may develope into serious engine failure.

If pistons have steel strut reinforcements at piston pin bosses,check for loose bond between strut & piston. Oil bubbles at point of bond when strut is moved, indicates loose bond.

PISTON SIZE-INSPECT

Piston fit to cylinder must be sufficiently tight to allow bottom of piston skirt to scrape some of the excess oil from cylinder walls & prevent piston rocking in cylinder bore, causing rapid piston ring wear.



Piston fit to cylinder must also be free enough to prevent binding & scoring.

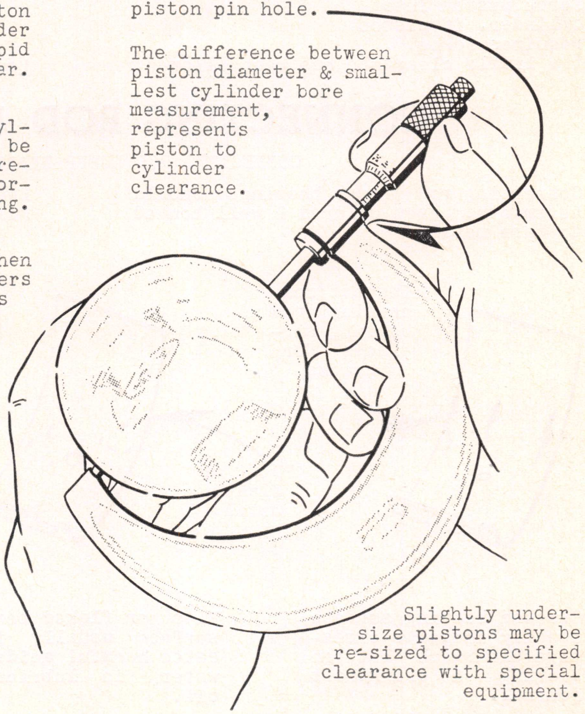
It is obvious then that manufacturers clearance limits must be closely followed.

After removing cylinder glaze measure cylinder bore as outlined in "CYLINDER BORE-INSPECT" to determine smallest diameter.

NOTE - Make measurements below ring travel portion of cylinder bore.

Using standard outside micrometers, measure diameter of piston skirt 1/4" above lower edge of skirt & 90° from piston pin hole.

The difference between piston diameter & smallest cylinder bore measurement, represents piston to cylinder clearance.

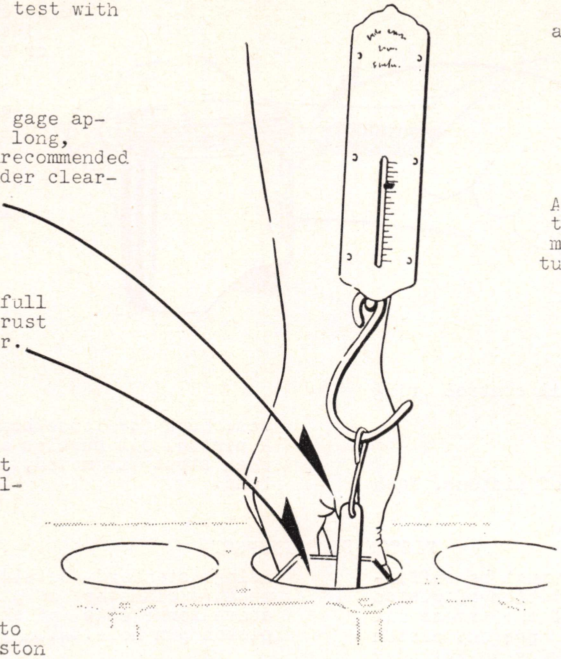


Slightly undersize pistons may be re-sized to specified clearance with special equipment.

NOTE- Re-size pistons to fit their individual cylinder bore.Test piston fit to cylinder before assembling to rod.

PISTON ASSEMBLIES

PISTON FIT TO CYLINDER-INSPECT



Make final piston to cylinder clearance test with feeler gage.

Select a feeler gage approximately 12" long, 1/2" wide & of recommended piston to cylinder clearance thickness.

Insert feeler, full length, into thrust side of cylinder.

Insert piston (inverted) about 1/2 way into cylinder bore.

CAUTION-Do not force piston into cylinder. If piston requires force, too little clearance has been allowed.

By attaching a pull scale to feeler gage, amount of pull required to withdraw feeler can be determined.

Amount of pull required to withdraw feeler gage must be within manufacturers specified limits.

NOTE- Some manufacturers specify dry feeler gage; some specify oiled feeler gage.

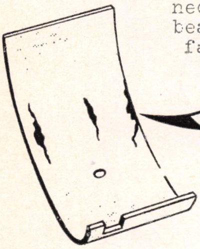
Pistons & cylinder block must be clean & at room temperature (approximately 70° F.) when testing.

CONNECTING ROD ASSEMBLIES

CONNECTING ROD LOWER BEARINGS-INSPECT

Connecting rod lower bearings should be smooth, even colored & well bonded to base metal.

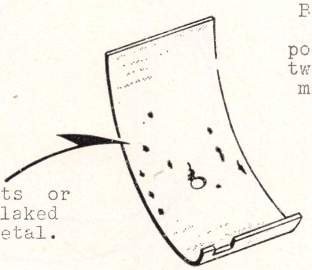
Bearings showing any of these defects must be replaced to prevent early bearing failures.



Inspect connecting rod bearing surfaces for cracks.

Cracked bearing surface usually indicate excessive clearance between bearing & crankshaft journal.

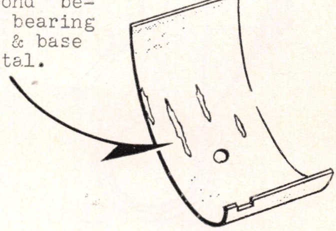
Look for out-of-round journal when this bearing failure is found.



Pits or flaked metal.

Pits or flaked bearing surface usually indicates harmful acids or water in lubricating oil.

Check crankcase ventilation when this failure is evident.



Bright spots, indicating poor bond between bearing metal & base metal.

Loose bond between the bearing metal & base metal is usually an indication of too much clearance between bearing & journal.

Check roundness of the crankshaft journal.

CONNECTING ROD ASSEMBLIES

CONNECTING ROD

Connecting rod type, weight & length from center of piston pin hole to center of lower bearing bore, are important points to check when ordering replacement parts.

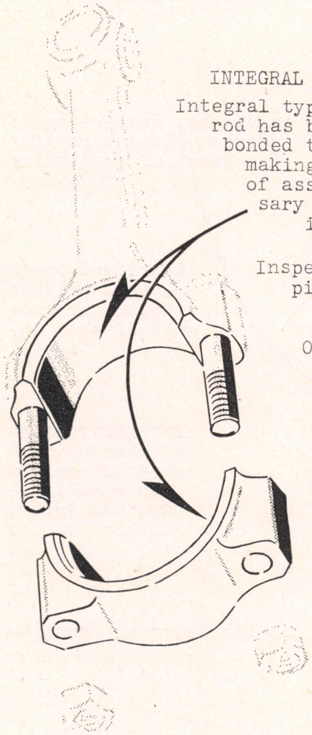
Type & length must be identical to the original equipment.

Weight of each rod must be equal within specified limits.

CONNECTING ROD INSPECTION

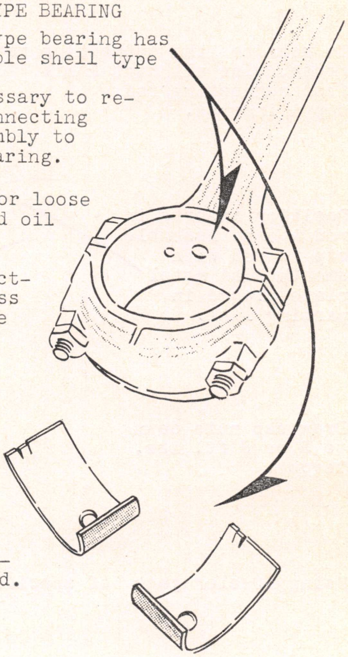
INTEGRAL TYPE BEARING

Integral type connecting rod has bearing metal bonded to rod & cap, making replacement of assembly necessary when bearing is defective.



INSERT TYPE BEARING

Insert type bearing has replaceable shell type bearing.
Not necessary to replace connecting rod assembly to renew bearing.



Inspect for improperly positioned or loose piston pin bushings & obstructed oil passages.

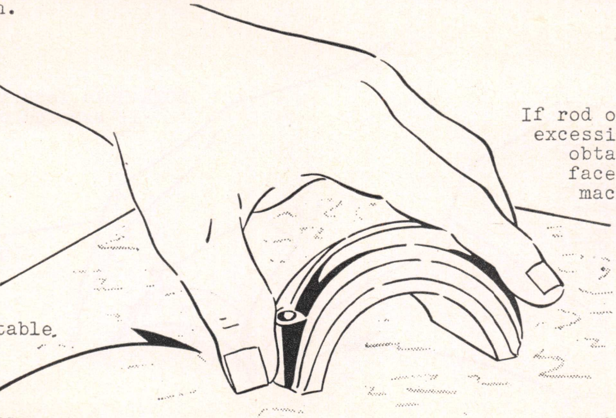
On "insert bearing" type connecting rods, place cap on rod (less inserts) & check bearing bore for out-of-round. If out-of-round, special equipment is necessary to relieve parting faces, rebore to standard size.

Lay straightedge across parting surfaces of rod & cap. If straightedge can be rocked, or if light shows under straightedge, the parting faces must be resurfaced.

PARTING SURFACES-RESURFACE

Slightly irregular parting surfaces on connecting rod or cap may be trued up with abrasive cloth.

Just a few strokes should be required.



NOTE-Avoid use of file to true up connecting rod or cap parting faces.

If rod or cap requires excessive grinding to obtain smooth surfaces, use special machine equipment to resurface parting faces & rebore bearing bore.

Place sheet of abrasive cloth on surface plate. Plate glass is suitable.

Exerting light pressure on rod or cap, move in circular motion over abrasive until desired surfaces are obtained.

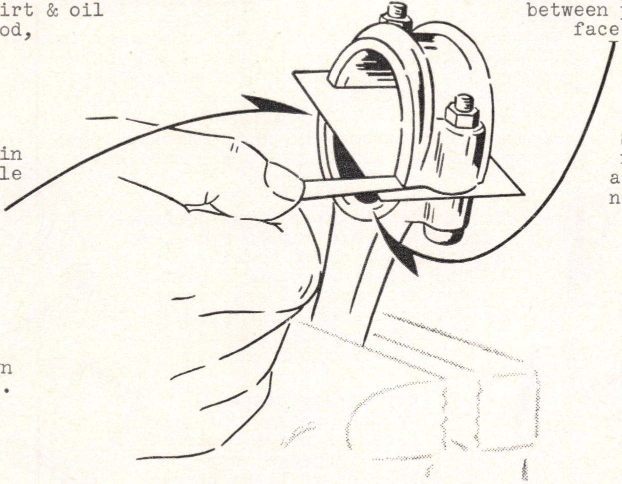
Caps & rods are bored as a unit & must be used in sets.

CONNECTING ROD ASSEMBLIES

BEARING CRUSH

Bearing crush is a term applied to the method of creating pressure between insert type bearings & supporting walls. Inserts must have tight contact with supporting walls to provide good bond for heat transfer, prevent oil leaks & loss of oil pressure. To accomplish this, inserts are designed so ends project slightly above parting faces of rod & cap. When cap nuts are tightened to recommended torque, inserts are compressed against supporting walls.

BEARING CRUSH-INSPECT



To measure the connecting rod bearing crush, wipe all dirt & oil from connecting rod, cap & inserts.

Position inserts in rod & cap. Assemble cap to rod with smooth flat metal plate placed in parting line.

Draw cap nuts down to 5 or 6 ft. lbs. torque.

Using feeler gage of specified crush thickness, measure space between plate & parting faces of connecting rod & cap.

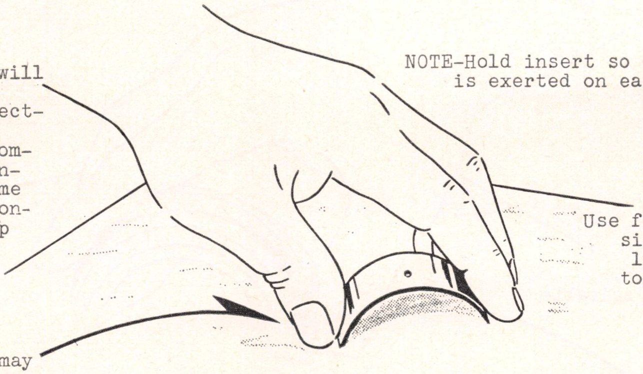
Specified crush must be evident at all four corners of both inserts.

Excessive crush on one insert & no crush on the other will allow one insert to move in its saddle.

Inserts with too little crush must be replaced.

EXCESSIVE CRUSH-RELIEVE

When installing new insert type bearings, always check crush allowance.



Excessive crush will cause inserts to buckle when connecting rod nuts are tightened to recommended torque tension &, in extreme cases, stretch connecting rod & cap metal.

Excessive crush may be relieved by moving insert, in circular motion, over piece of abrasive cloth backed with surface plate.

Plate glass makes a suitable surface plate.

NOTE-Hold insert so equal pressure is exerted on each side of insert.

Use fine grit abrasive cloth. Apply lubricating oil to abrasive surface.

When desired crush is obtained, thoroughly clean all abrasives from inserts.

CONNECTING ROD ASSEMBLIES

PISTON PINS-INSPECT

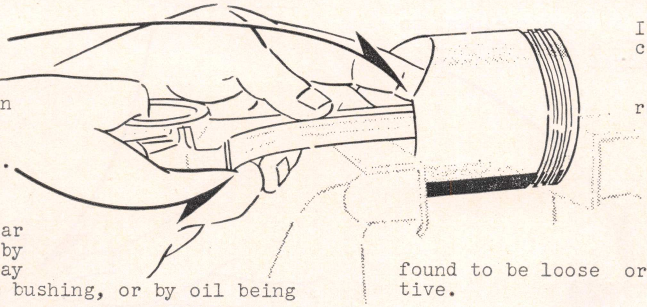
Piston pins play an important part in oil control & piston performance. Loosely fitted pins, particularly on engines employing forced feed lubrication to piston pins, allow excessive oil to reach cylinder walls. Oil pumping will result.

Tight piston pin fit will not allow proper piston expansion & contraction, causing piston distortion & possible piston scoring.

Consult engine manufacturers specifications for clearances.

PISTON PIN-VISUAL INSPECTION

Place piston in vise fitted with copper jaws, or in regular piston vise.



While holding upper end of rod centered between piston bosses, move lower end of rod up & down.

Piston pin wear is indicated by noticeable play between pin & bushing, or by oil being forced out of bearing surfaces in piston bosses, when rod is moved.

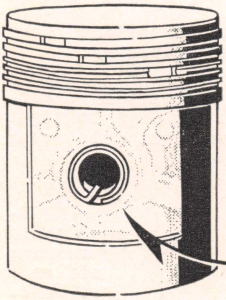
If either of these conditions are evident or if bushing is loose in rod, new parts must be installed.

Visually inspect piston pin locks for tightness.

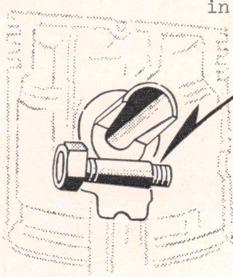
Replace locks if found to be loose or otherwise defective.

PISTON PIN LOCKS-REMOVE

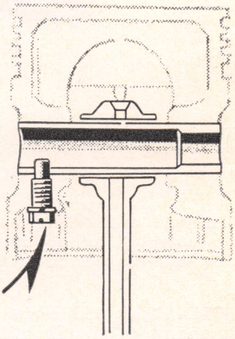
Various types of piston pin locks may be encountered.



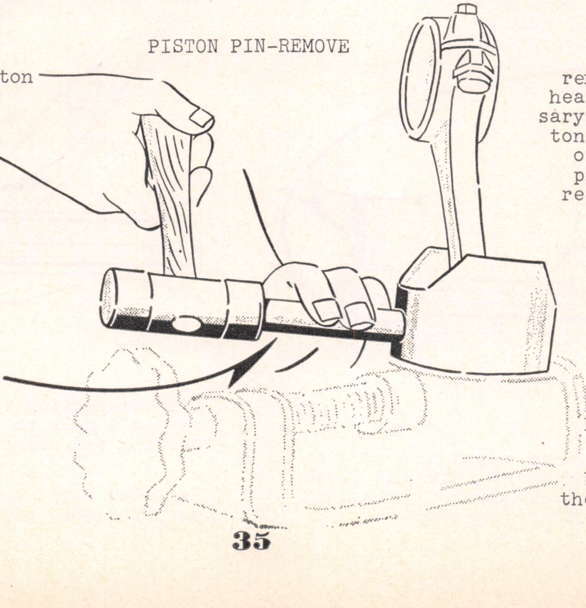
Full floating pins employ lock rings at each end of pin.



Semi-floating type may use clamp bolt in rod, allowing pin to move in piston bosses, or it may employ a lock pin in piston boss, allowing pin to move in upper connecting rod bushing.



PISTON PIN-REMOVE



Prior to removing piston pin, make slight file mark on inner edge of piston skirt to correspond with identifying mark on piston, so they will be assembled in same relative position.

By using brass drift & hammer, a few light taps will remove pin.

NOTE-Some pistons require heating before removing pin. If heating is necessary, submerge piston in hot water, or place on hot plate to obtain recommended temperature.

Lay pistons, pins & connecting rods in rotation on bench for further inspection.

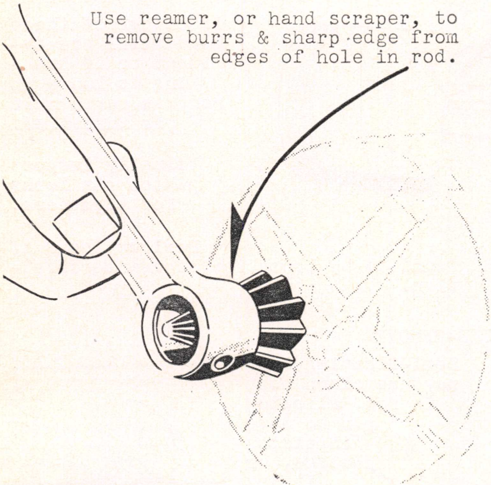
CONNECTING ROD ASSEMBLIES

CONNECTING ROD BUSHING-INSPECT

Inspect connecting rod bushing for tightness in rod; alinement of oil hole in bushing with oil hole in rod; for piston pin fit to bushing bore. If the bushing is loose in rod or if oil hole is misalined, install new bushing.

CONNECTING ROD BUSHING-INSTALL

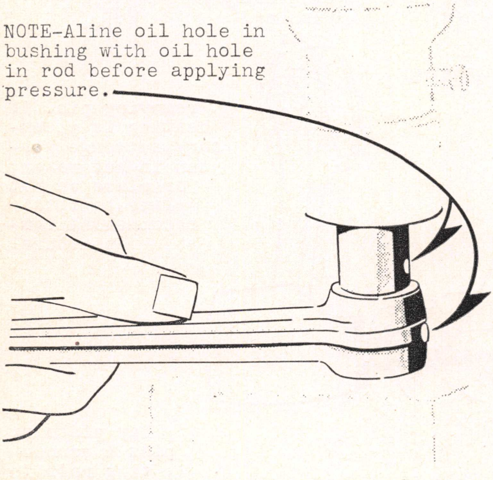
Using suitable bushing removing tool & arbor press, remove old bushing.



Use reamer, or hand scraper, to remove burrs & sharp edge from edges of hole in rod.

The slight chamfer left from removing sharp edges aids installation of new bushing.

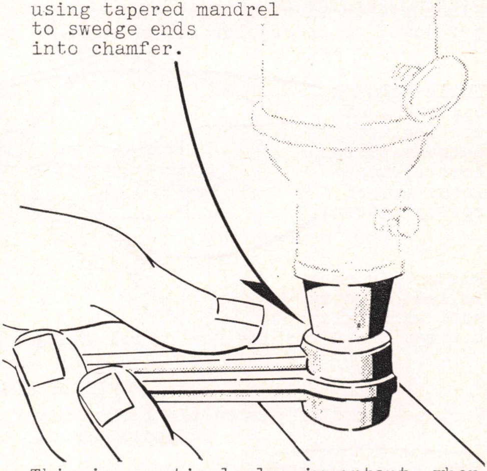
Support end of connecting rod squarely on base of arbor press while pressing new bushing into place.



NOTE-Aline oil hole in bushing with oil hole in rod before applying pressure.

Press bushing into connecting rod to desired position, ends of bushing flush or equal amount of bushing extending from edges of connecting rod.

Lock bushing into connecting rod by using tapered mandrel to swedge ends into chamfer.

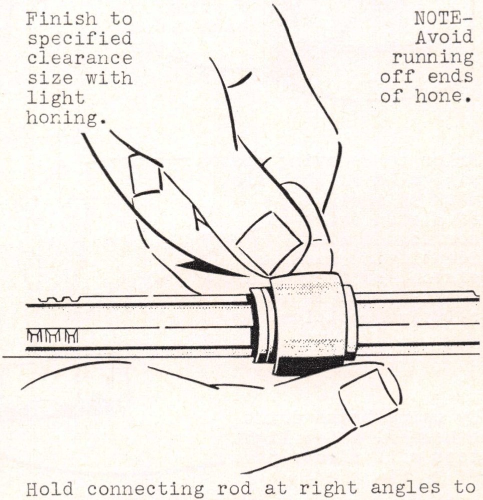


This is particularly important when thin wall bushings are employed.

To bore bushing to piston pin clearance fit, rough cut bushing to tight push fit by repeated light cuts with adjustable reamer.

Finish to specified clearance size with light honing.

NOTE-Avoid running off ends of hone.



Hold connecting rod at right angles to reamer & hone to assure piston & connecting rod alinement when assembled.

Repeated light cuts & tests are necessary for good piston pin fit.

PISTON ASSEMBLIES

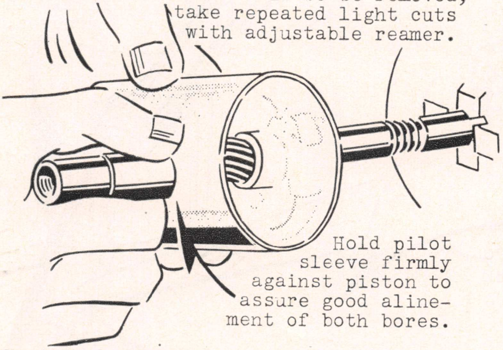
PISTON PIN

Piston pin fit to piston is of special importance. If fitted too tight, piston expansion & contraction is retarded resulting in piston & cylinder scoring. If fitted too loose, excessive oil pumping & noise may occur. When possible, have pin holes diamond bored for accurate bearing surface. When diamond bore equipment is not available, the following may be employed.

PISTON PIN-FIT TO PISTON

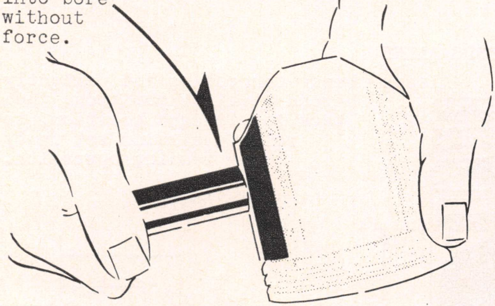
NOTE - Certain specifications call for tighter fit at one end of piston pin than at the other. Consult engine manufacturers specifications for clearance limits.

If considerable metal is to be removed, take repeated light cuts with adjustable reamer.



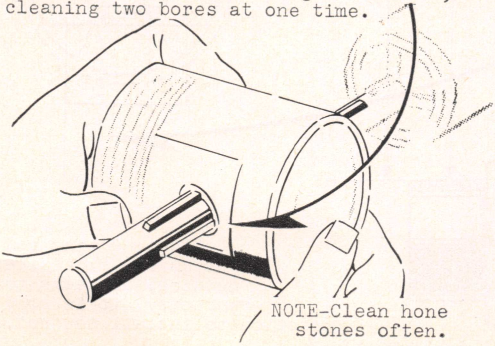
Hold pilot sleeve firmly against piston to assure good alinement of both bores.

Test bores with piston pin after each cut. Stop when pin can just be started into bore without force.



Finish bore with piston pin hone for final pin fit.

When pin fit is same in both bosses, stroke piston full length of hone, cleaning two bores at one time.

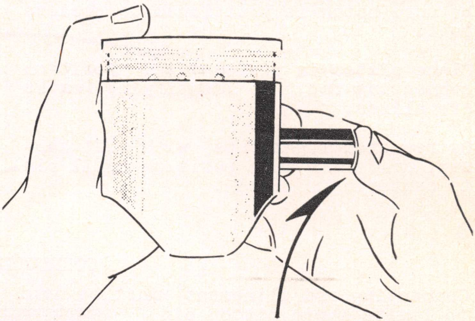


NOTE-Clean hone stones often.

Check manufacturers specifications for temperature recommendation for final piston pin fit.

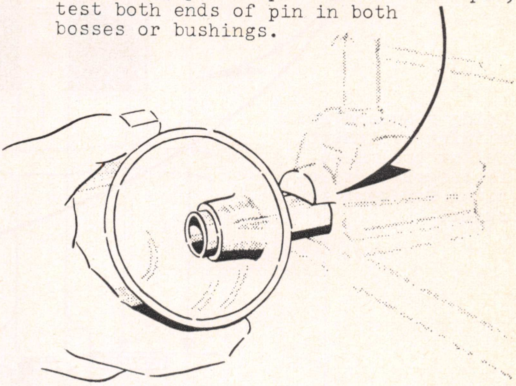
If piston specifications call for temperature above average room heat(70°F) submerge pistons in water heated to specified temperature or place on hot plate, until desired temperature is obtained.

Wipe both bosses with clean cloth before inserting piston pin for test.



If thumb push fit is desired, pin must slide through both bosses with thumb pressure at specified temperature.

When using piston pin vise to hold pin, test both ends of pin in both bosses or bushings.



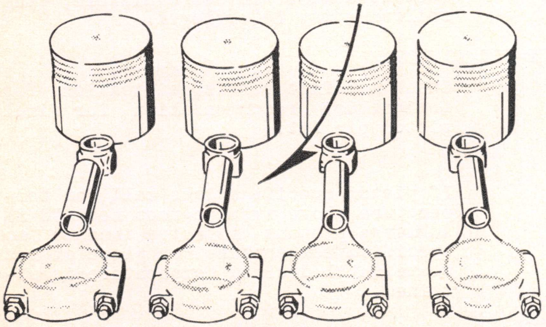
Repeat operation on all pistons until all pins are fitted.

Be certain pins are used in pistons to which they were fitted.

PISTON & CONNECTING ROD ASSEMBLIES

ASSEMBLE PISTONS TO CONNECTING RODS

Arrange pistons,connecting rods & piston pins on clean portion of bench, in same order as origional installation, indicated by marks on rods & pistons.



Heat piston, if necessary,& enter piston pin through boss on one side of piston.If pin is notched for lock bolt, be sure notch is positioned to recieve bolt.

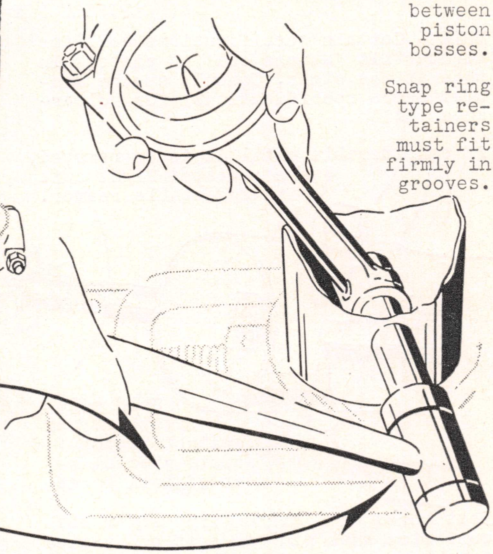
Place piston in piston vise. Position connecting rod, so identifying marks are alined.

By repeated light taps with soft hammer, drift pin into position until pin is centered in piston.

Piston pin must not extend beyond edges of piston when moved from side to side.

Install pin lock.If clamp type lock is used, be sure upper end of rod is centered between piston bosses.

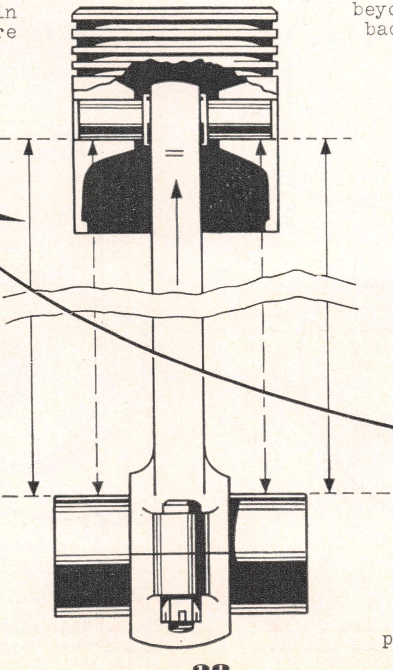
Snap ring type retainers must fit firmly in grooves.



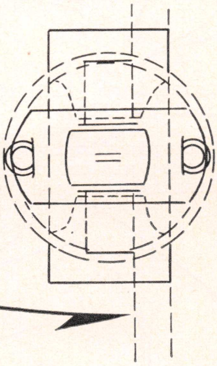
CONNECTING RODS-ALINE

Connecting rod alinement must be held to limits where piston pin & alining tool mandrel are parallel in both lateral & vertical planes.

Always bend connecting rod slightly beyond straight position, then back to straight position, to relieve strains set up by bending operation.



Using standard rod alining equipment, follow tool manufacturers instructions for best results.



Tighten cap bolt nuts to recommended torque tension to assure proper crush condition.

If connecting rod requires excessive bending, or seems to bend easy, it is good practice to install new rod.

PISTON RINGS

PISTON RINGS

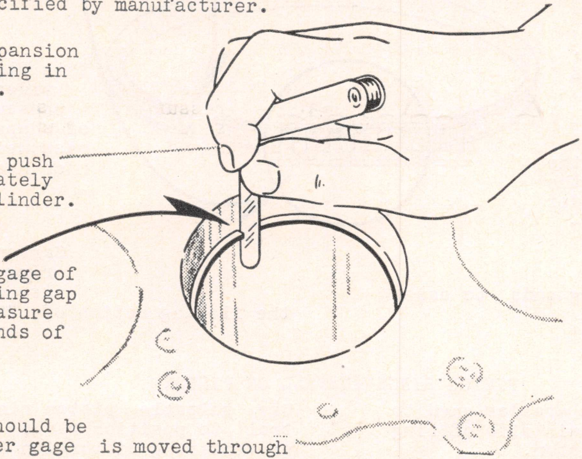
Compression rings are seals that hold forces of combustion in the combustion chambers where energy is spent delivering power to pistons. They must also dissipate some excess heat, generated by combustion, to the cooling system.

Oil rings seal excess oil from combustion chambers, but also must provide light oil film for cylinder wall lubrication. Most rings must fit in cylinders & piston grooves with clearances allowing certain flexing action.

PISTON RING-FIT TO CYLINDER (Butt End Type)

Piston ring fit to cylinder must allow for ring expansion (ring gap), unless otherwise specified by manufacturer.

If gap is less than specified limits, use special tool, or fine cut file to relieve ring ends.



To measure expansion gap, insert ring in cylinder bore.

Use piston to push ring approximately 2" down in cylinder.

Using feeler gage of recommended ring gap thickness, measure gap between ends of ring.

Slight drag should be felt as feeler gage is moved through gap.

Place ring in vise, equiped with copper jaws & take light file cuts over ends of ring to obtain specified gap.

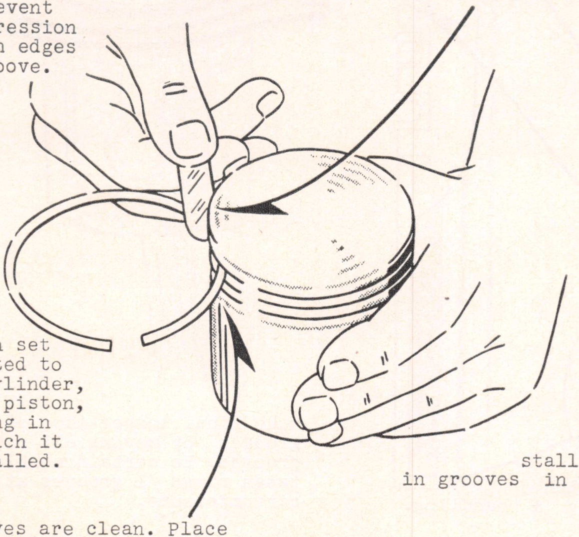
Fit rings in sets for each individual cylinder & install in cylinder to which they were fitted.

Be certain rings are seated square against cylinder walls when measuring ring gap

PISTON RING-FIT TO PISTON

Piston ring fit to piston grooves must be free enough to allow free movement of ring, yet tight enough to prevent loss of compression & oil between edges of ring & groove.

Then insert feeler gage of recommended ring to groove clearance thickness between ring & ring land.



Starting with set of rings fitted to number one cylinder, & number one piston, test each ring in groove in which it will be installed.

Be sure grooves are clean. Place ring in groove (inverted) & roll ring completely around groove to test for bind at all points of circumference.

Roll ring & feeler gage around piston & test clearance at several places.

A slight drag should be felt when feeler gage is moved.

Tight spots may be caused by burrs on ring lands or on piston rings.

Using suitable ring installing tool, install rings in grooves in which they were tested.

As a final check for tight spots, move the rings around, also back & forth in grooves.

PISTON RINGS

PISTON RINGS-FIT TO CYLINDER (SEGMENT TYPE)

It is often desirable to use a segment oil control ring in slightly worn or tapered cylinders.Follow ring manufacturers instructions for best results.

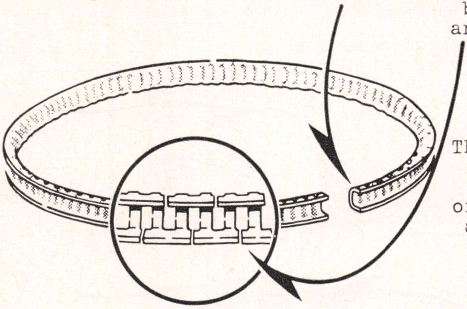
"U FLEX" OIL CONTROL RINGS

Some engine manufacturers employ the "U FLEX" oil control ring as original equipment.

The spring like action of the "U FLEX" piston ring assures uniform cylinder wall pressure, long life, non-clogging & non-fluttering performance.

Normal free length of the "U FLEX" ring exceeds the circumference of cylinder bore in which it is installed.

NOTE - Do not file ring ends to cause ring gap.



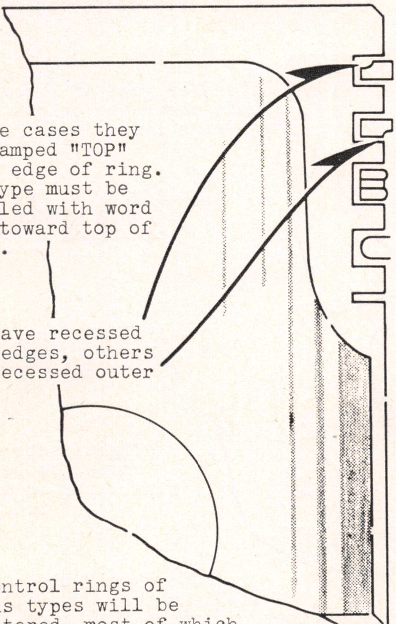
When compressed into cylinder, with ring ends tightly butted together,gaps between "U" segments are partially closed, resulting in spring action.

This flexibility provides uniform wall pressure regardless of shape cylinder has assumed through wear or heat distortion.

Carbon formation at ring drain area is also discouraged by the flexing action of "U FLEX" ring.

PISTON RINGS-INSTALL ON PISTON

Many compression rings are designed to be installed with certain side of ring faced toward top of piston.



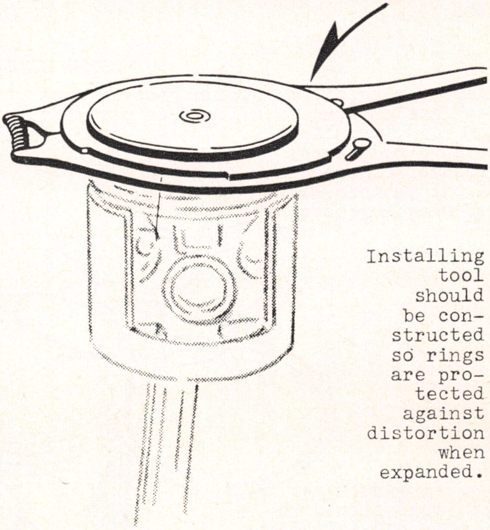
In some cases they are stamped "TOP" on one edge of ring. This type must be installed with word "TOP" toward top of piston.

Some have recessed inner edges, others have recessed outer edges.

Oil control rings of various types will be encountered, most of which require special fitting & handling.

Follow manufacturers instructions for information on installation procedures.

Use suitable piston ring installing tool to position rings on piston to prevent ring distortion & breakage.



Installing tool should be constructed so rings are protected against distortion when expanded.

Make final inspection of ring fit to grooves by moving all rings around in grooves. Be certain no bind exists between rings & grooves at any point of circumference.

Space ring gaps evenly around piston circumference.

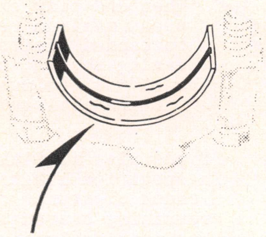
MAIN BEARINGS

CRANKSHAFT (MAIN) BEARINGS

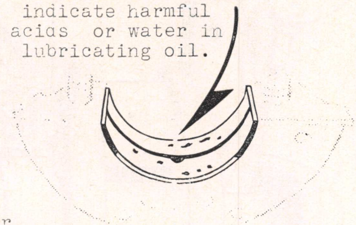
Main bearings must hold crankshaft in perfect alinement. When one bearing needs replacing, the entire set must be replaced; Most modern engines use steel backed, precision shells, accurately finished to standard & undersize shaft journals requiring no further fitting.

MAIN BEARING-VISUAL INSPECTION

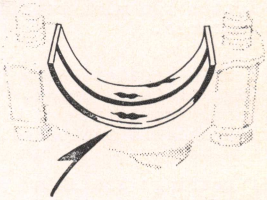
Main bearing surfaces should be smooth, even colored & well bonded to the base metal. If one or more bearings show any of these defects, replace complete set (upper & lower shells).



Inspect bearing surfaces for cracks, looseness in cap & crush.



Pits of flaked metal indicate harmful acids or water in lubricating oil.



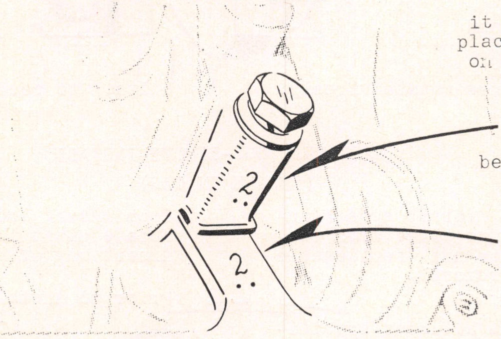
Bright spots indicate loose bond between bearing metal & base metal.

BEARINGS-IDENTIFY

Main bearing bores are machined with caps in position.

To interchange bearing caps, or to reverse a cap on its own support, will cause heavy bearing to journal contact at some point & often cause broken bearing cap.

To prevent difficulties of this kind, it is good practice to place identifying marks on bearing caps before removal.

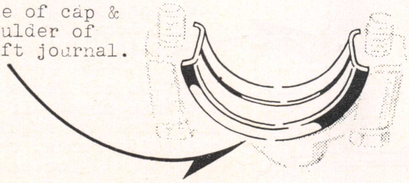


Using number die or center punch, mark bearing caps in their order of position, starting at front bearing. Also mark support adjacent to cap mark.

Be certain all the caps are installed with marks in register in all bearing test operations.

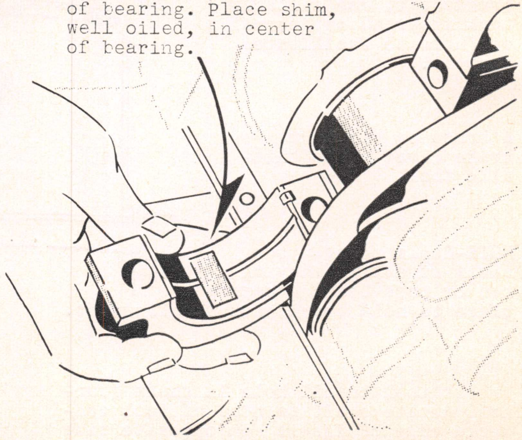
BEARING CLEARANCE-TESTS

Locate bearing which governs crankshaft end play, identified by thrust flanges between each side of cap & shoulder of shaft journal.

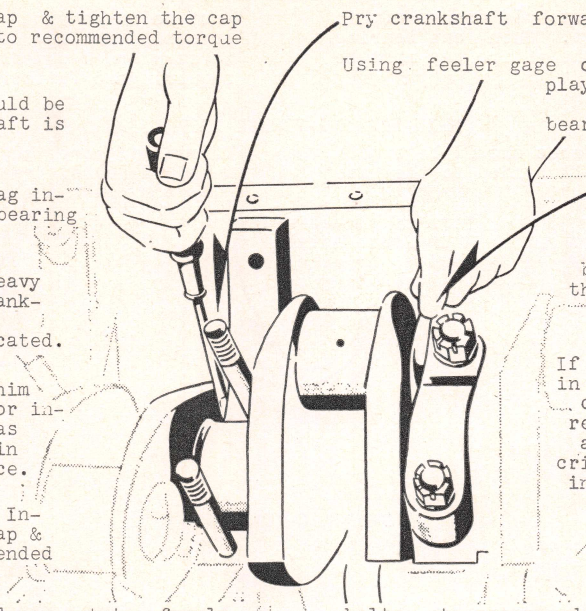


Remove bearing cap & bearing. If bearing & shaft journal pass visual inspection, proceed with clearance test.

Secure piece of shim stock 1/2" wide, of recommended clearance thickness & approximately 1/4" shorter than width of bearing. Place shim, well oiled, in center of bearing.



MAIN BEARINGS



Install bearing cap & tighten the cap bolts, or nuts, to recommended torque tension.

A slight drag should be felt when crankshaft is rotated.

No perceptable drag indicates too much bearing clearance.

If shim creates heavy drag, or locks crankshaft, too little clearance is indicated.

If bearings are shim adjusted, remove or install thin shims as necessary to obtain specified clearance.

Remove test shim. Install bearing & cap & tighten to recommended torque.

Crankshaft should now rotate freely.

Pry crankshaft forward, or backward.

Using feeler gage of recommended end play thickness, measure space between bearing thrust face & crankshaft thrust face.

When end play exceeds maximum recommended limits, bearing shells, or thrust washers must be replaced.

If end play is within specified limits, check clearance on remaining bearings, as previously discribed, making bearing & shaft journal inspection before making test.

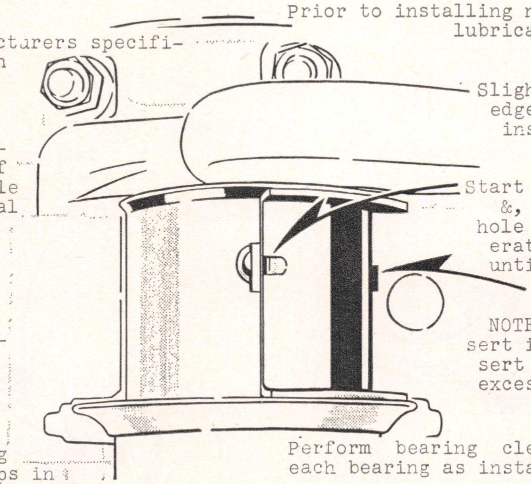
Tighten all bearing cap nuts, or bolts, to recommended torque tension.

MAIN BEARINGS-REMOVE-INSTALL

(ENGINE IN CAR)

Upper half of some insert type bearings are fastened into place with dowels or screws & are not replaceable without crankshaft removal.

Consult engine manufacturers specifications for information on type used.



When insert is replaceable without removal of crankshaft, use suitable tool inserted in journal oil hole to facilitate removal.

A brass or aluminum brake rivet makes suitable tool.

NOTE-Replace one upper shell at a time, leaving two or more bearing caps in place to hold crankshaft in alinement.

Insert tool in oil hole in shaft journal. Rotate shaft so head of tool contacts edge of insert on opposite side from insert locating lug. Continue to rotate shaft in same direction, rolling insert out of crankcase saddle.

Prior to installing new insert, be sure lubricating oil passages are clear.

Slightly chamfer sharp edge of plain side of insert to facilitate installation.

Start insert into place &, using tool in oil hole as in removal operation, rotate shaft until locating lug is seated in recess.

NOTE-Do not force insert into place. If insert binds or requires excessive force, check for cause.

Perform bearing clearance test for each bearing as installed.

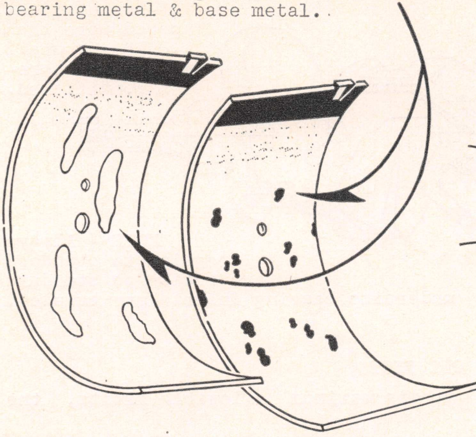
Tighten all bearing cap nuts, or bolts to recommended torque tension.

See "MAIN BEARINGS-REPLACE" (engine out of car) for procedures when engine is removed.

MAIN BEARINGS

MAIN BEARINGS-INSPECT

Visually inspect bearing surfaces for pits, scores, flaked metal or bright spots indicating loose bond between bearing metal & base metal.



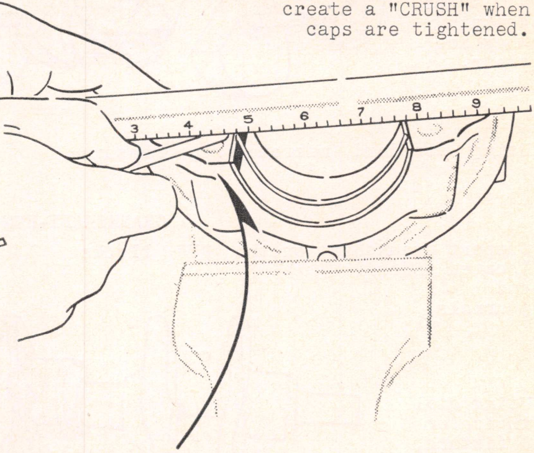
If one or more bearings are found to be defective, replace entire set to maintain crankshaft alinement.

Precision shell type bearings may be used as is. However it is often desirable to use un-finished or undersize shells & line bore to size.

Integral type bearings must always be line reamed.

With precision shell type bearings, it is important to maintain heavy pressure contact between the base metal of shells & supporting metals to provide good heat transfer & prevent shell movement.

To accomplish this, bearing shells are made so ends extend slightly beyond supporting surfaces to create a "CRUSH" when caps are tightened.

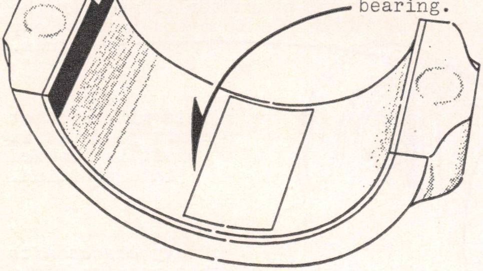


Using straightedge & feeler gage, measure crush of each bearing shell in its respective position.

MAIN BEARING CLEARANCE-TEST

Select a piece of shim stock of thickness for recommended running clearance. Cut shim stock 1" long & of width 1/4" less than width of bearing.

Apply light coat of lubricating oil to shim stock & place in center of cap bearing.

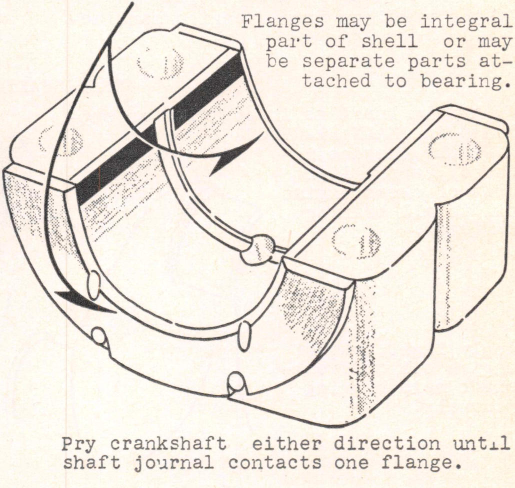


Position bearing cap & tighten bolts or nuts to specified torque tightness. Slight drag should be felt when crankshaft is rotated.

No drag indicates the clearance is too great. Replace bearing. Under no condition must bearing cap be filed to fit bearing.

Crankshaft end play is controlled by one or more bearing flanges.

Flanges may be integral part of shell or may be separate parts attached to bearing.

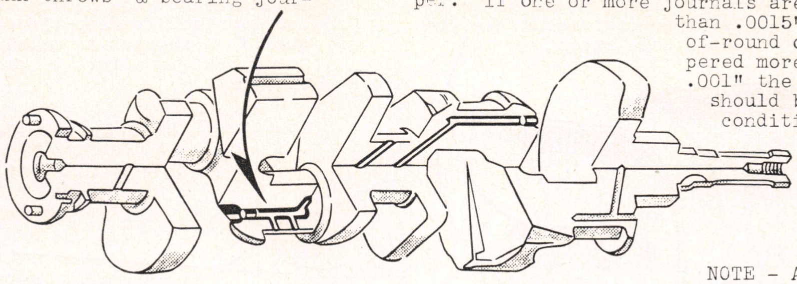


Pry crankshaft either direction until shaft journal contacts one flange.

Measure distance from opposite flange to crankshaft journal flange. If distance exceeds specified end play limits, replace necessary parts.

CRANKSHAFT

CRANKSHAFT JOURNALS-INSPECT (ENGINE REMOVED)



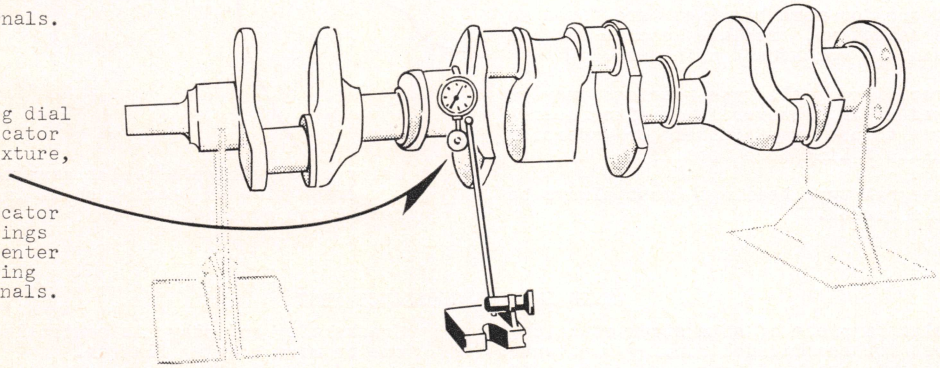
Thoroughly clean all drilled oil passages in crank throws & bearing journals.

Test each passage with compressed air to be certain they are clear.

Using standard micrometers, measure each journal for out-of-round or taper. If one or more journals are more than .0015" out-of-round or tapered more than .001" the shaft should be reconditioned.

NOTE - Always regrind to standard undersize, so standard undersize bearing inserts may be used.

CRANKSHAFT-RUN OUT TEST

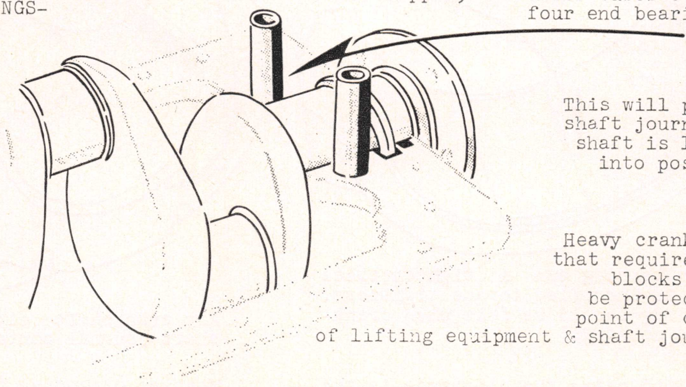


Support crankshaft on two "V" blocks located under end journals.

Using dial indicator & fixture, take dial indicator readings at center bearing journals.

If the readings exceed engine manufacturers maximum allowable limits, the shaft must be straightened or replaced.

CRANKSHAFT-INSTALL



With main bearings in position as outlined in "MAIN BEARINGS-INSTALL" (Engine Removed), apply light coat of clean engine oil to all bearing surfaces.

Apply light coat of engine oil to crankshaft main bearing journals.

Extra caution should be used to prevent damage to bearing journals when positioning crankshaft in engine.

Place copper, or rubber tubes over the four end bearing cap studs.

This will protect shaft journals as shaft is lowered into position.

Heavy crankshafts that require chain blocks should be protected at point of contact of lifting equipment & shaft journals.

Install bearing caps. Tighten attaching bolts,or nuts, to specified torque tension.

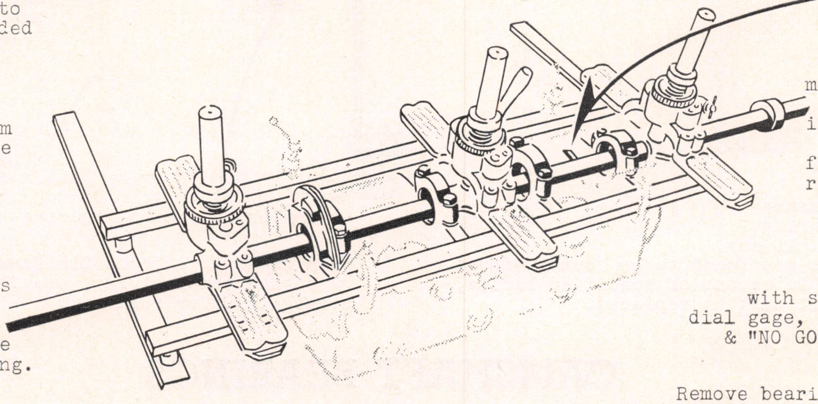
MAIN BEARINGS

MAIN BEARINGS-INSTALL (ENGINE REMOVED)

Where shell type bearings are used, remove all oil, dirt & burrs from bearing saddles, caps & shell backs to assure good contact between shells & supporting metals.

Holding shells firmly in their respective saddles & caps, measure portion of shells extending above parting faces (bearing crush). Consult manufacturers specifications for crush limits.

MAIN BEARINGS-LINE BORE



Place bearing caps in position & then tighten cap bolts, or nuts to recommended torque tension.

When shim packs are used, be certain equal number of shims of equal thickness are in place at each side of bearing.

Using standard micrometers, measure crankshaft journals. Allow for specified bearing running clearance when setting cutting tools.

Follow tool manufacturers instructions for best results.

Check final results with suitable dial gage, or "GO" & "NO GO" gage.

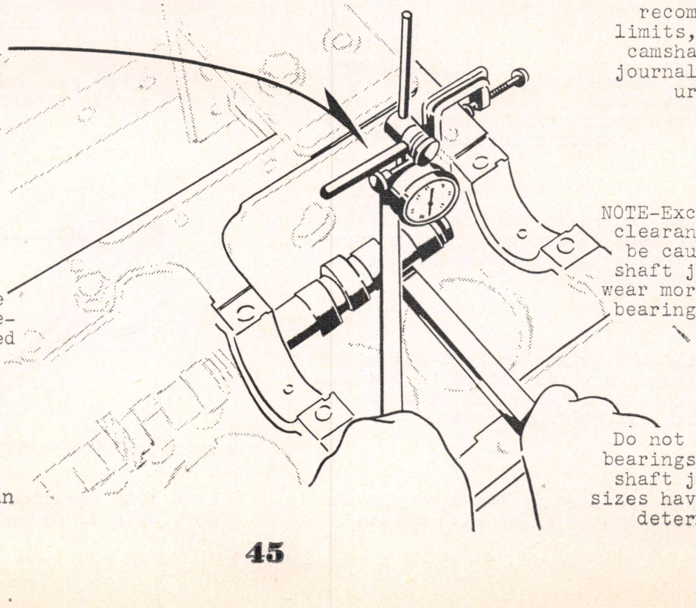
Remove bearing caps for crankshaft installation.

Blow cuttings from bearings & oil passages.

CAMSHAFT BEARINGS

On some engines all camshaft bearings are replaceable shell type, while on other engines one or more bearings are bored into, & are an integral part of, the block. When necessary to replace bearings, engine should be removed.

CAMSHAFT BEARINGS-MEASURE (ENGINE REMOVED)



If preliminary oil pressure test indicated excessive oil leakage at camshaft bearings, attach dial indicator to engine block so indicator plunger is resting on back of cam nearest bearing.

By prying shaft toward & away from the indicator, shaft movement will be recorded on indicator dial.

Check each bearing in same manner.

If clearance exceeds the manufacturers recommended limits, remove camshaft for journal measurement.

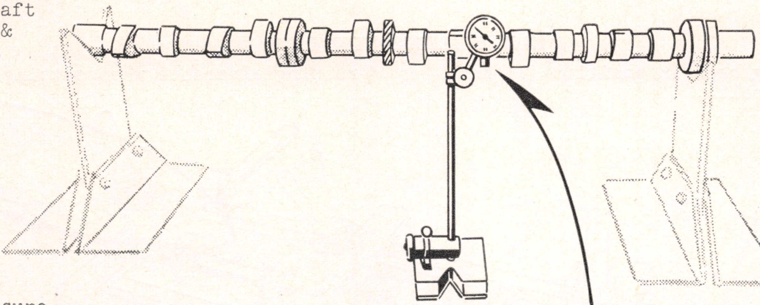
NOTE-Excessive clearance may be caused by shaft journal wear more than bearing wear.

Do not remove bearings until shaft journal sizes have been determined.

CAMSHAFT

CAMSHAFT-INSPECT

If preliminary oil pressure tests indicate excessive camshaft bearing clearance, remove camshaft & inspect for worn shaft bearing journals, shaft run-out & worn cam lobes.



Using standard micrometers measure each bearing journal. If any journals are found to be out-of-round or worn in excess of specified limits, the shaft must be replaced.

If journals are in useable condition, make note of diameters to be used against bearing bore sizes when calculating running clearances.

Support camshaft on two "V" blocks.

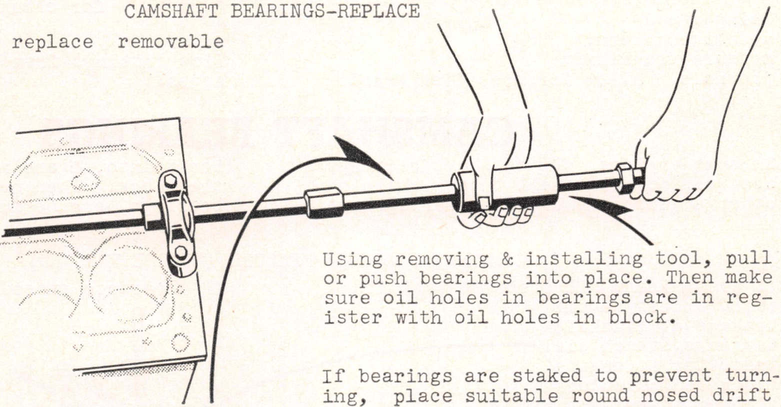
Using dial indicator, check for run-out at center camshaft bearing journal.

When run-out exceeds limits specified by engine manufacturer, shaft must be straightened or replaced.

CAMSHAFT BEARINGS

CAMSHAFT BEARINGS-REPLACE

When necessary to replace removable type camshaft bearings, special removing & installing equipment is required.



To drive bearings out or in may damage bearing bores in block.

Using suitable tool, remove camshaft bearings. The tool illustrated is designed to remove & install bearings.

Remove any burrs in bearing bores that may have been caused by removing operation. Be certain all lubricating oil holes are clear.

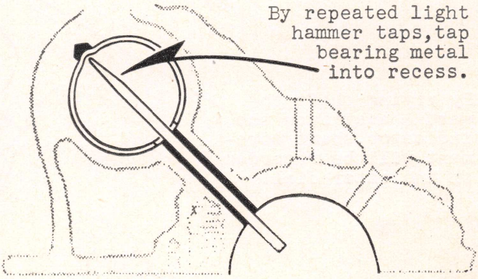
To facilitate alinement of oil holes in bearings with oil holes in bearing bores, make marks on sides of bores in line with oil holes in bores.

Start new bearings in bores so the oil holes in bearings aline with marks.

Using removing & installing tool, pull or push bearings into place. Then make sure oil holes in bearings are in register with oil holes in block.

If bearings are staked to prevent turning, place suitable round nosed drift through lubricating oil hole.

By repeated light hammer taps, tap bearing metal into recess.



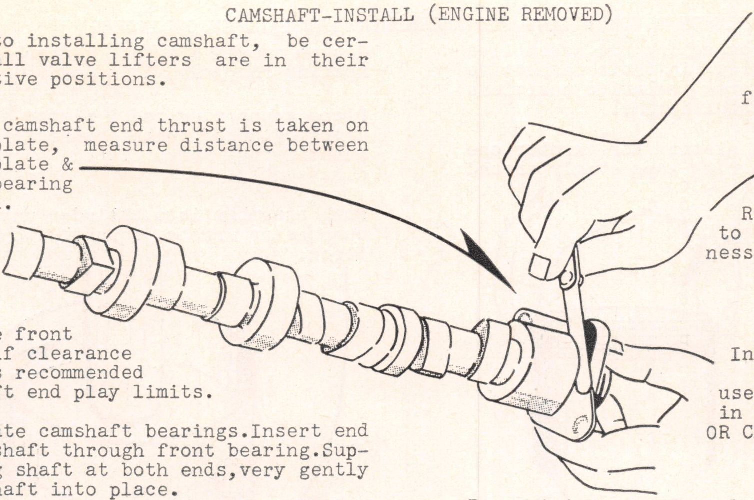
Line ream bearings to running clearance size if necessary.

CAMSHAFT BEARINGS

CAMSHAFT-INSTALL (ENGINE REMOVED)

Prior to installing camshaft, be certain all valve lifters are in their respective positions.

If the camshaft end thrust is taken on front plate, measure distance between front plate & front bearing journal.



Replace front plate if clearance exceeds recommended camshaft end play limits.

Lubricate camshaft bearings. Insert end of camshaft through front bearing. Supporting shaft at both ends, very gently move shaft into place.

NOTE - Extreme care must be used when positioning camshaft in block to prevent damage to bearings.

When shaft is positioned in block, make final clearance check.

Rotate camshaft to test for freeness of operation.

Install camshaft drive gear, if used, as outlined in "CAMSHAFT GEAR OR CHAIN-INSTALL".

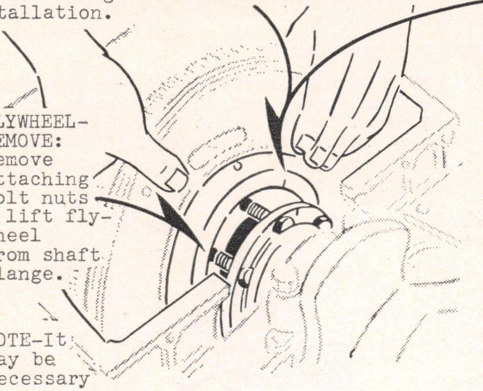
Be certain expansion plug at rear camshaft bearing bore is properly installed to prevent oil leak at this point.

FLYWHEEL

FLYWHEEL-REMOVE & INSTALL

Most flywheel attaching bolts are unevenly spaced so correct relation between timing marks & crank pins will be maintained when the flywheel is installed.

However it is good practice to scribe a line on face of flywheel & crankshaft flange to facilitate correct installation.



FLYWHEEL-REMOVE: Remove attaching bolt nuts & lift flywheel from shaft flange.

NOTE-It may be necessary to tap rim of flywheel with soft hammer to start flywheel from flange.

FLYWHEEL-INSPECT: Examine flywheel ring gear for worn or broken teeth. Inspect clutch friction surface for wear. Using one of the attaching bolts, check all bolt holes for wear.

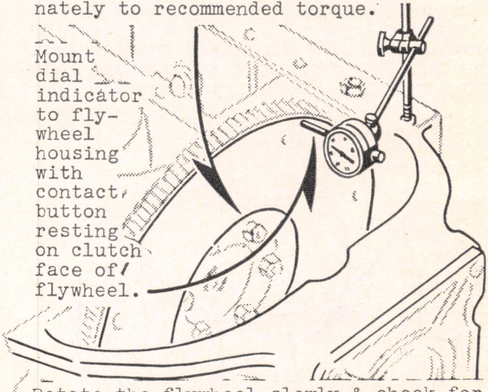
If the bolt does not fit snug in bolt holes, flywheel should be replaced.

Replace ring gear if teeth are worn or broken.

FLYWHEEL - INSTALL: Remove all burrs, dirt or chips from crankshaft flange & recess in flywheel.

Aline previously made scribe mark on flywheel with mark on flange. Move flywheel into place.

Tighten attaching bolts evenly & alternately to recommended torque.



Mount dial indicator to flywheel housing with contact button resting on clutch face of flywheel.

Rotate the flywheel slowly & check for run-out. If run-out exceeds specified limits, make necessary adjustments or replace flywheel.

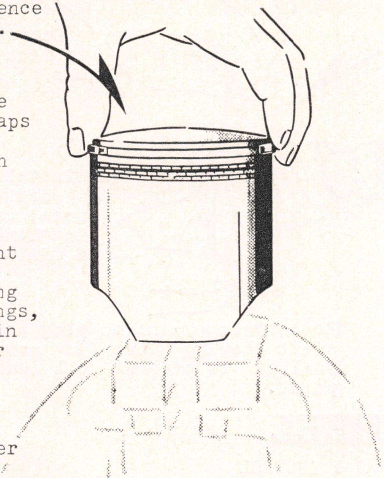
Excessive run-out may seriously effect clutch action & cause excessive engine vibration at certain speeds.

PISTON & CONNECTING ROD ASSEMBLIES

PISTON & CONNECTING ROD ASSEMBLIES (INSTALL IN CYLINDERS)

The piston & connecting rod assemblies must be installed in their respective cylinders in same relative positions as original installations.

Starting with piston for number one cylinder,space ring gaps evenly around circumference of piston.



NOTE-Space so ring gaps straddle piston pin holes.

Apply light coat of lubricating oil to rings, piston, pin & cylinder wall.

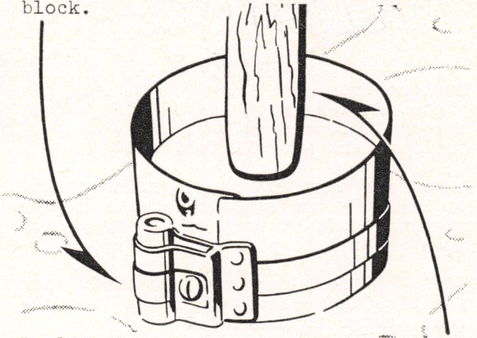
Place upper end of connecting rod in vise fitted with soft jaws.

Place ring compressor tool over rings &, while tapping compressor band with light hammer,contract compressor until band is just snug around piston.

Rotate crankshaft so number one connecting rod journal is down.

Place connecting rod & piston assembly into cylinder with connecting rod identifying marks faced as noted on disassembly.

Push assembly into cylinder until ring compressor rests squarely on top of block.



By lightly tapping top of piston with hammer handle,or wooden block,tap piston into cylinder.

Remove bearing cap;position connecting rod on shaft journal & install cap.

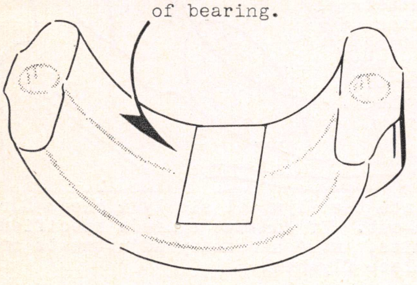
Tighten cap nuts finger tight.

Install remaining piston & connecting rod assemblies in same manner.

CONNECTING ROD BEARING-FIT TO JOURNALS

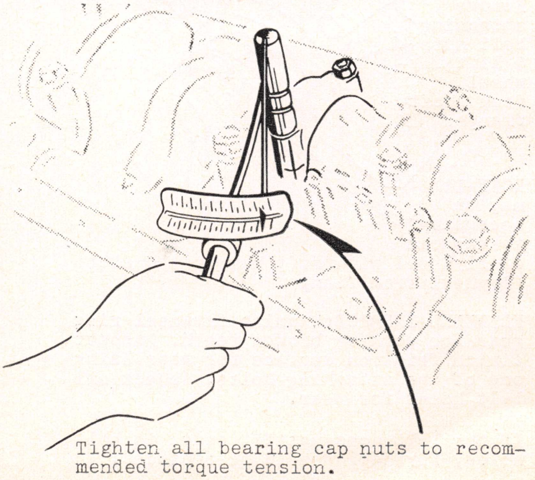
To check connecting rod bearing fit to crankshaft journals, select a piece of shim stock 1/2" wide,1/4" shorter than width of bearing & of recommended bearing running clearance thickness.

Place shim in center of lower half of bearing.



Position cap on connecting rod,identifying marks in register, & tighten cap nuts to recommended torque tension.

Shim should snug bearing so lower end of connecting rod will not move across journal by hand but will slide across with light tap of hammer.



Tighten all bearing cap nuts to recommended torque tension.

OIL PUMP

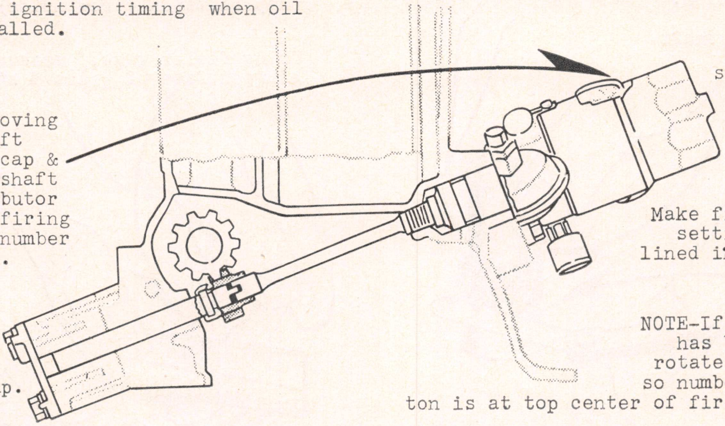
Some oil pumps are located inside engine, making it necessary to remove oil pan for pump removal & installation.

Others are located outside the engine, usually directly opposite distributor. Pan removal not necessary.

OIL PUMP-REMOVE-INSTALL

REMOVE: On many engines the oil pump shaft drives the ignition distributor. It is necessary, when this type distributor drive is used, to establish approximate ignition timing when oil pump is installed.

INSTALL: Position oil pump shaft in approximate position to allow distributor shaft drive to register with drive end of oil pump shaft.



Prior to removing oil pump, lift distributor cap & rotate crankshaft until distributor rotor is in firing position on number one cylinder.

Remove pump attaching screws & pump.

NOTE - Do not move crankshaft while pump is off engine.

Install oil pump, being sure distributor shaft remains in correct position.

Make final timing setting as outlined in "TUNE-UP" section.

NOTE-If crankshaft has been moved, rotate crankshaft so number one piston is at top center of firing stroke.

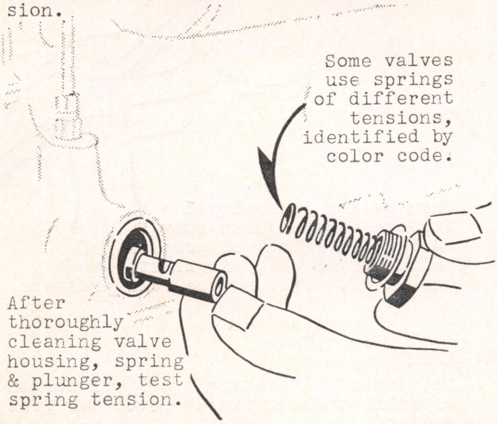
Set distributor rotor to fire on number one cylinder. Install oil pump. Set timing.

OIL PRESSURE RELIEF VALVE

Oil pressure relief valves are used in engine lubricating systems, to relieve high oil pump pressures & maintain predetermined line pressures. Some relief valves are incorporated in oil pumps, others are mounted seperately.

RELIEF VALVE-INSPECT

The relief valve adjustment is accomplished by changing valve spring tension.

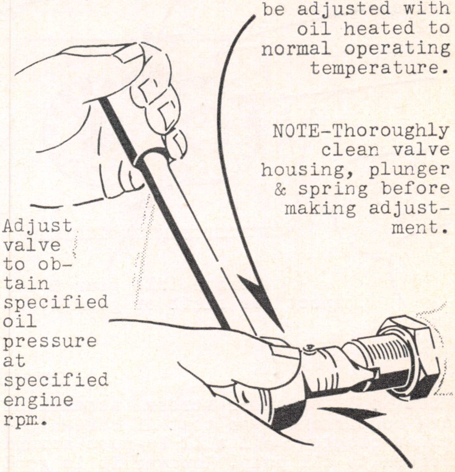


Some valves use springs of different tensions, identified by color code.

After thoroughly cleaning valve housing, spring & plunger, test spring tension.

When spring tension is not within specified limits, use new spring of same color.

Manually adjusted relief valves must be adjusted with oil heated to normal operating temperature.



NOTE-Thoroughly clean valve housing, plunger & spring before making adjustment.

Adjust valve to obtain specified oil pressure at specified engine rpm.

Turn adjusting screw clockwise to increase oil pressure reading.

LUBRICATION

Lubrication of engine parts plays an important part in their useful life.

It is good practice to examine the lubrication system, paying particular attention to the oil pump, pressure regulator & oil strainer screen.

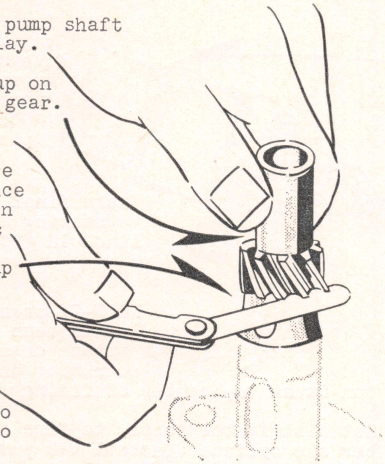
The two types of oil pump most commonly used are the gear type & rotor type

GEAR TYPE OIL PUMP-INSPECT

Worn oil pump parts prevent normal pump operation.

Check pump shaft end play.

Pull up on drive gear.

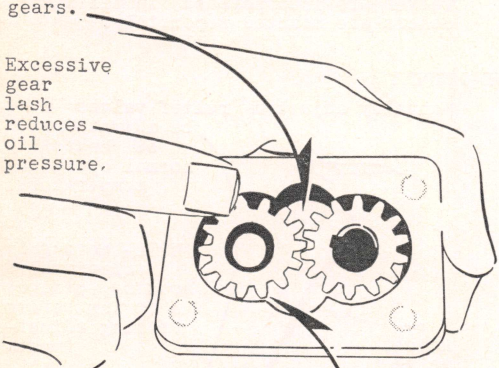


Measure distance between gear & shank of pump body.

Move shaft from side to side to determine amount of shaft & bearing wear.

If excessive end play or side play exists, pump must be reconditioned.

Remove pump cover & check lash between gears.

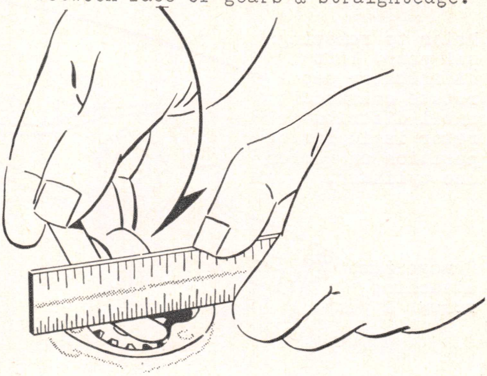


Excessive gear lash reduces oil pressure.

Remove idle gear & inspect for shaft or gear wear.

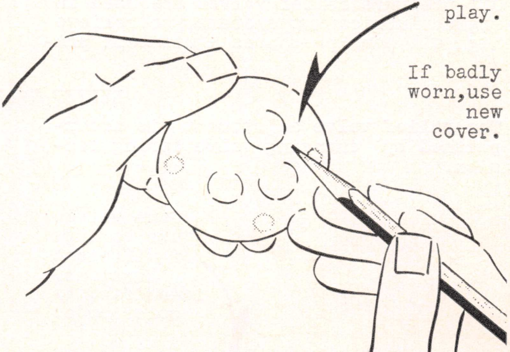
Place straightedge or scale across the pump (between screw holes).

Using feeler gage, measure clearance between face of gears & straightedge.



When clearance exceeds specified limits, use new housing & gears.

Examine pump cover for wear caused by excessive end play.



If badly worn, use new cover.

When gasket is employed between cover & pump body, be certain gasket of proper thickness is used. A gasket, too thick, will reduce oil pressure.

OIL STRAINER SCREEN

Most oil strainer screen assemblies are constructed so that if screen becomes clogged, oil will by-pass around screen to oil pump. However it is good policy to clean oil screen each time the oil pan is removed.

On pivoted (floating type) oil screen assemblies be certain pivot has free action.

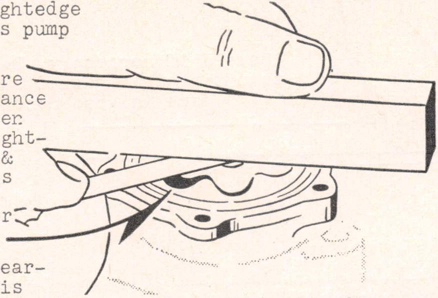
Check for possible leakage at fitting where suction pipe attaches to engine case.

LUBRICATION

ROTOR TYPE OIL PUMP

Clearance limits are important factors in rotor type oil pump operation. Excessive clearances allow oil to by-pass pump rotors, reducing oil pressure

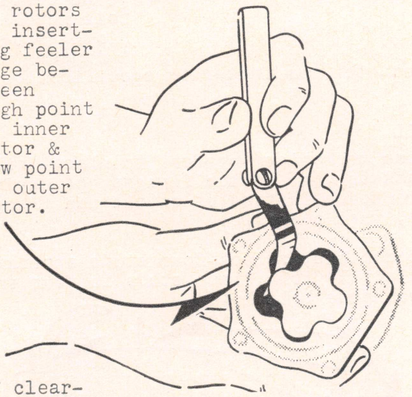
ROTOR PUMP-INSPECT



With pump cover & gasket removed, place straightedge across pump body.

Measure clearance between straightedge & rotors with feeler gage.

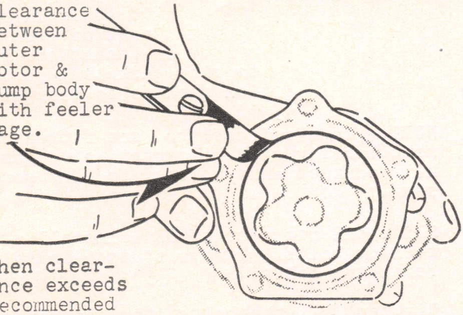
If clearance is in excess of recommended limits disassemble pump for further inspection.



Measure clearance between inner & outer rotors by inserting feeler gage between high point of inner rotor & low point of outer rotor.

If clearance is in excess of car manufacturers specifications, replace both rotors.

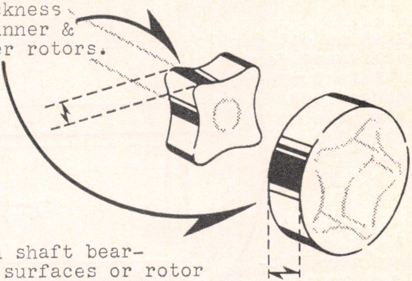
Examine both rotors for wear, nicks, burrs, scratches or scoring. Replace parts if damaged.



Move outer rotor to one side & measure clearance between outer rotor & pump body with feeler gage.

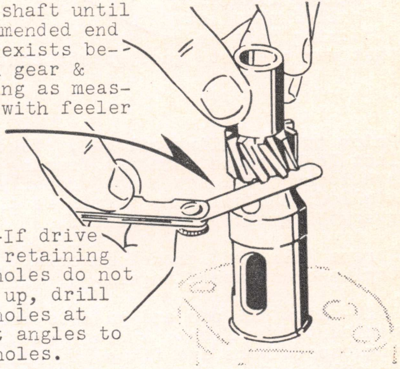
When clearance exceeds recommended limits, remove outer rotor & measure outside diameter with micrometers.

Replace parts as necessary to obtain specified clearance limits.



Using standard micrometers, measure bearing surfaces of pump shaft, & thickness of inner & outer rotors.

When shaft bearing surfaces or rotor thickness are worn in excess of specifications, use new parts.

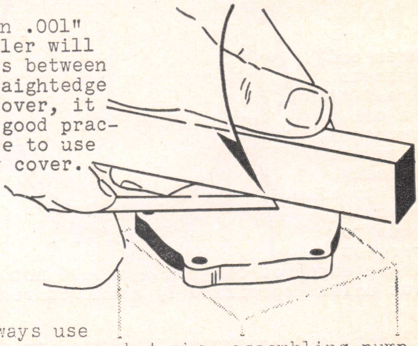


When assembling pump, press drive gear onto shaft until recommended end play exists between gear & housing as measured with feeler gage.

NOTE-If drive gear retaining pin holes do not line up, drill new holes at right angles to old holes.

Peen both ends of drive gear retaining pin.

The pump cover must be smooth, free of groove marks & scratches.



Lay straightedge across inner surface of cover & check with feeler gage.

When .001" feeler will pass between straightedge & cover, it is good practice to use new cover.

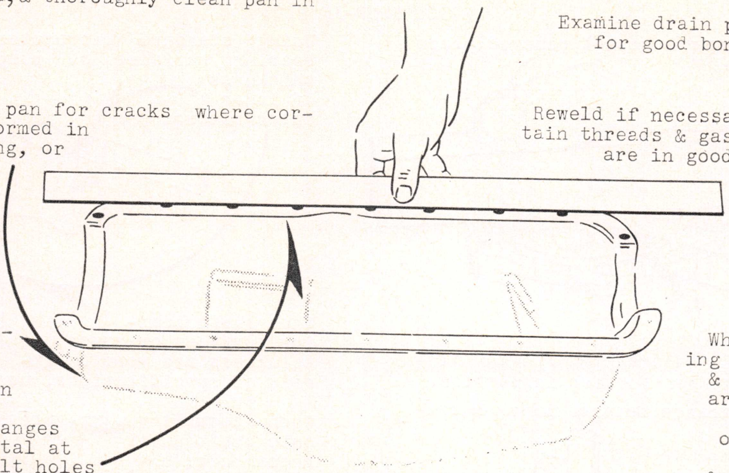
Always use new cover gasket when assembling pump. Tighten the cover screws evenly to assure uniform cover to gasket contact.

OIL PAN

OIL PAN-INSPECT

Inspect oil pan for possible causes of oil leaks. Scrape old gasket material from oil pan flanges, remove end gaskets, if used, & thoroughly clean pan in solvent.

Examine oil pan for cracks where corners were formed in manufacturing, or where rocks may have caused a puncture.



Lay straightedge across each side flange of pan to check for irregular flanges or pulled metal at attaching bolt holes that may prevent good gasket contact.

Straighten flanges where necessary.

Examine drain plug fitting for good bond with pan.

Reweld if necessary. Be certain threads & gasket surface are in good condition.

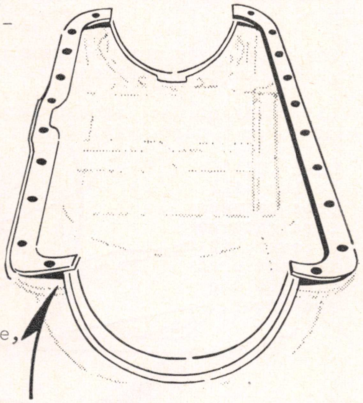
When connecting rod dippers & oil troughs are employed, be certain oil nozzles, oil troughs & dippers are set to manufacturers specifications.

OIL PAN-INSTALL

Prior to installing oil pan, take one last look to be sure all bearing nuts are locked; oil seals are properly installed; the oil pump screen is clean; everything else is in order.

Scrape all old gasket material from engine crankcase flanges.

NOTE- Some oil pan end gaskets are cemented to the front & rear main bearing caps, others are fitted in recesses in oil pan. Consult manufacturers specifications for installation methods.

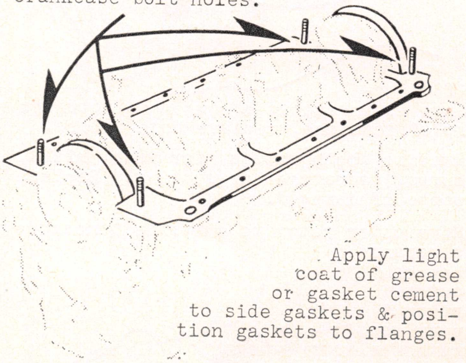


When end gaskets are fitted in oil pan recesses, they are usually cut to size, allowing ends to project above edges of oil pan & should not be cut unless specified by manufacturer.

Cement side gaskets in place on oil pan flanges so ends are resting on top of end gaskets.

Some mechanics prefer to place side gaskets on bottom flanges of engine crankcase instead of on oil pan flanges, when possible.

To do this, select four studs approximately 1" long. Place studs in four end crankcase bolt holes.



Apply light coat of grease or gasket cement to side gaskets & position gaskets to flanges.

NOTE - When end gaskets are fitted to main bearing caps, be certain side gaskets contact end gaskets to form good seal.

Slide oil pan over studs & install attaching bolts. Remove studs & install remaining bolts.

Tighten all the bolts to recommended torque.

Fill oil pan to proper level with recommended weight of oil.

CRANKSHAFT OIL SEALS

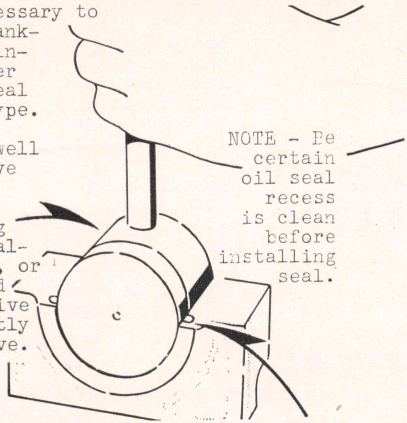
CRANKSHAFT REAR BEARING OIL SEAL

Excess oil that may pass between crankshaft journal & rear main bearing is directed back to the oil pan by means of an oil seal, a slinger machined on the crankshaft & an oil drain hole in the rear main bearing cap.

Several types of oil seals are used.

OIL SEAL-INSTALL

OIL SEAL FITTED TO BEARING CAP & CRANKCASE: Necessary to remove crankshaft to install upper half of seal on this type.



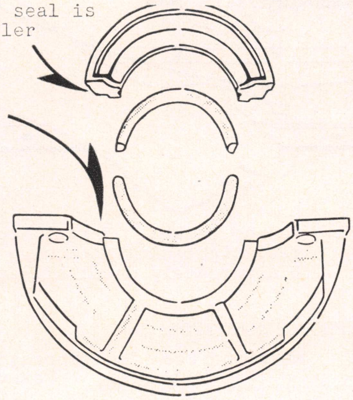
Fit seal well into groove by hand.

Then using seal installing tool, or round wood block, drive seal tightly into groove.

NOTE - Be certain oil seal recess is clean before installing seal.

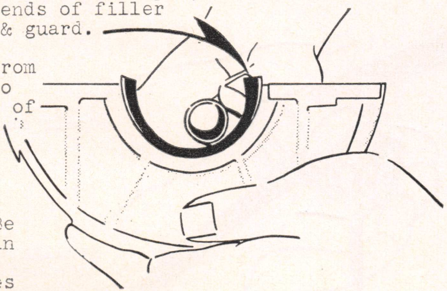
With tool, compressing seal, use sharp knife to cut seal ends off flush with cap or crankcase.

SEAL FITTED TO FILLER BLOCK & GUARD: Upper half of seal is fitted to filler block guard. Lower half is fitted to filler block.



Filler block guard can usually be removed for upper seal replacement without removing crankshaft.

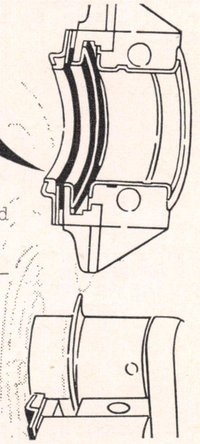
Use round mandrel & carefully roll the seal halves firmly into grooves, leaving ends of seals projecting slightly above ends of filler block & guard.



Roll from ends to center of seals.

NOTE-Be certain seal grooves are clean before inserting the seals.

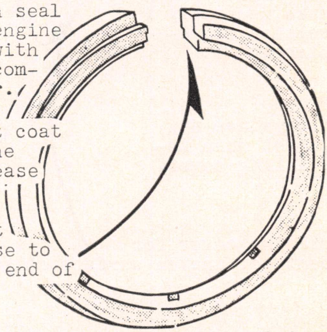
SEAL FITTED TO METAL RETAINER - BOLTED ON: Necessary to remove flywheel to install upper half of this type seal.



When replacing lower seal, retainer bolts should be left loose until bearing cap is tightened to recommended torque.

Then locate seal on shaft & tighten seal retainer bolts. Be certain retainer gasket & bearing end gaskets are in position.

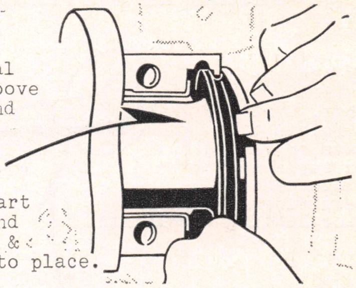
ONE PIECE OIL SEAL: After removing old seal, clean seal recess in engine crankcase with solvent & compressed air.



Apply light coat of glycerine soap or grease to seal.

NOTE-Do not allow grease to pile up on end of seal.

Start one end of seal in groove, wiping edge forward.



Push seal into groove until end is near top of bearing.

Then start other end of seal & work into place.

Be certain bearing flange slips into place in seal when installing bearing.

For further details on installing rear bearing seals see manufacturers section of "REPAIR & TUNE-UP MANUALS.

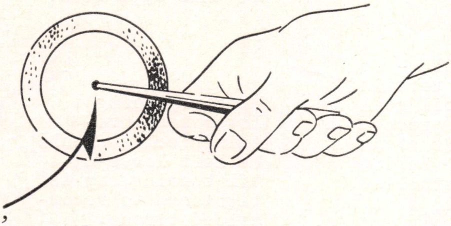
COOLING SYSTEM

The cooling system is the final means of ridding engines of excessive heat. Heat dissipation must be controlled to prevent loss of power, damaged engine parts, high oil & fuel consumption resulting from engine overheating.

EXPANSION PLUGS

Examine all expansion plugs for evidence of leaks as indicated by rust streaks.

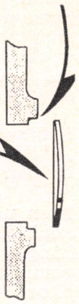
When leaks are indicated, bore 1/4" hole in center of expansion plug.



Insert small drift punch in hole & by exerting prying action, expansion plug can easily be removed.

Thoroughly clean expansion plug recess.

Apply light coat of non-hardening seal paste to outer edge of plug.



Install plug with convex side facing "OUT".

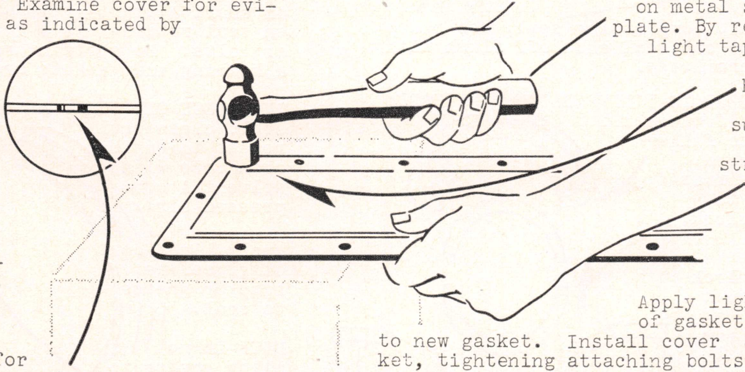
Expand in recess with blunt drift & hammer.

WATER JACKET PLATES

Some heavy duty engines employ water jacket covers. Examine cover for evidence of leaks as indicated by rust streaks.

Remove cover & make necessary repairs or replacements.

Always use new gasket when installing cover.



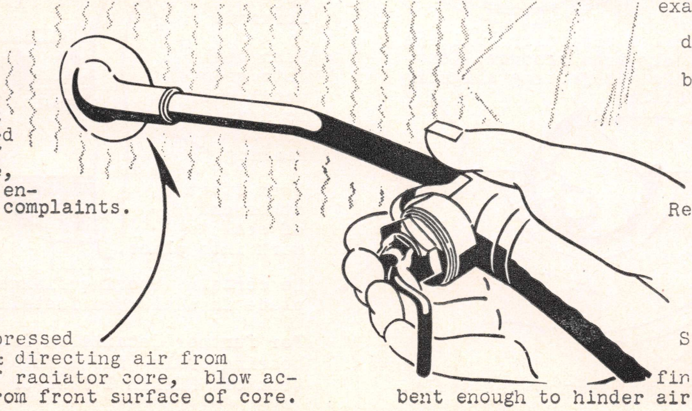
Examine cover for bent or uneven surface at bolt holes.

When gasket surface is uneven, place it on metal surface plate. By repeated light taps with small hammer, uneven surfaces may be straightened.

Apply light coat of gasket cement to new gasket. Install cover & gasket, tightening attaching bolts evenly & alternately until all are tight.

AIR CIRCULATION THROUGH RADIATOR

Air circulation through radiator core is often greatly retarded by accumulation of bugs, dirt & leaves that have collected on surface of radiator core, resulting in engine heating complaints.



By using compressed air fixture & directing air from rear side of radiator core, blow accumulation from front surface of core.

When surface is thoroughly cleaned, examine radiator core for evidence of leaks as indicated by rust spots.

Repair as needed.

Straighten any air deflector fins that may be bent enough to hinder air circulation.

COOLING SYSTEM

REVERSE FLUSH COOLING SYSTEM

Reverse flushing of cooling system is accomplished by forcing air & water through the system in opposite direction to normal flow. Loosening & disposing of rust, scale & sediment deposits is the result.

THERMOSTAT-INSPECT

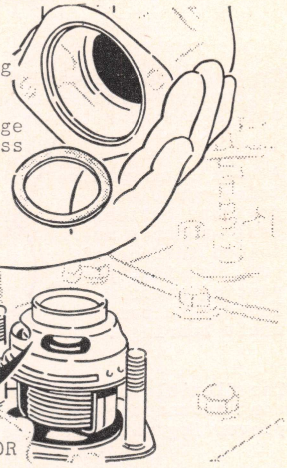
A thermostatically operated valve is often used in the cooling system to prevent water circulation through the radiator until engine reaches normal operating temperature.

Test thermostat for proper opening, & full open, temperatures.

To test, place thermostat & a thermometer in a pail of water. Heat water until thermostat starts to open.

Check water temperature reading with recommended thermostat opening temperature.

Replace thermostat if defective.

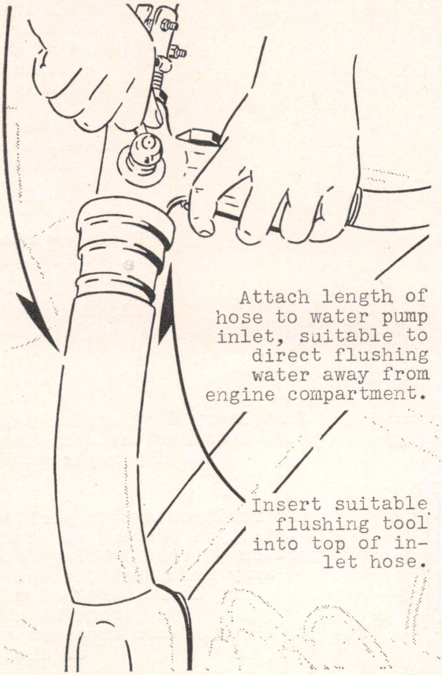


When installing by-pass type thermostat, be sure thin bridge dividing by-pass ports points toward front, leaving wide ports to right & left.

REVERSE FLUSH CYLINDER BLOCK & RADIATOR

With radiator & engine water jacket drained, remove thermostat.

Disconnect inlet hose at radiator connection, leaving lower end of hose connected to engine.



Attach length of hose to water pump inlet, suitable to direct flushing water away from engine compartment.

Insert suitable flushing tool into top of inlet hose.

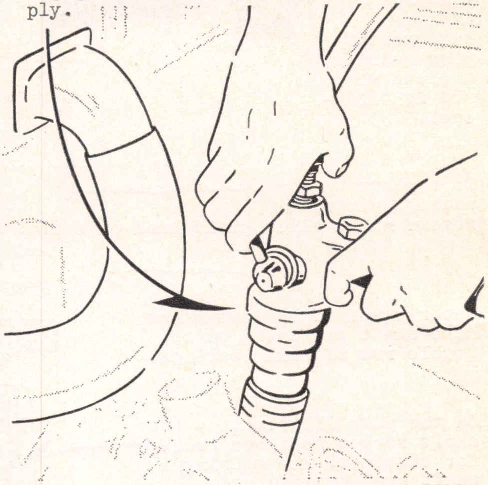
Use pulsating flow of water & air pressure until discharged water is clear.

Install thermostat. Install hoses & fill cooling system.

Drain radiator & disconnect top hose from inlet connection at top of radiator.

Attach long length of hose, suitable to carry contaminated water away from engine, to radiator connection.

Disconnect radiator outlet hose at outlet tube, & insert suitable flushing gun connected to water & air supply.



Turn on water until radiator is full. Then turn on air pressure, in short blasts, until water from discharge hose is clear.

CAUTION - Apply air pressure gradually when radiator is known to be clogged.

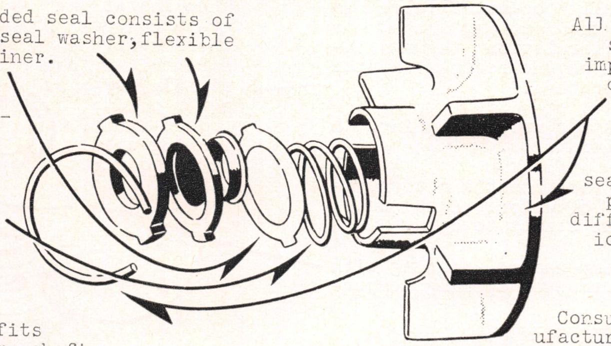
A good cleaning solvent, used with reverse flushing, will assist cleaning.

COOLING SYSTEM

WATER PUMP

Water pumps may be classed in two general types. "Spring Loaded Seal" type used on most passenger car & light truck engines; "Packing Ring & Gland" type, used on some heavy duty engines, usually mounted on side of engine.

WATER PUMP SEAL-SPRING LOADED



Typical spring loaded seal consists of a fibre or carbon seal washer, flexible seal & a seal retainer.

A coil spring maintains constant pressure between seal washer & machined surface of pump housing, preventing water leakage to pump shaft bearings.

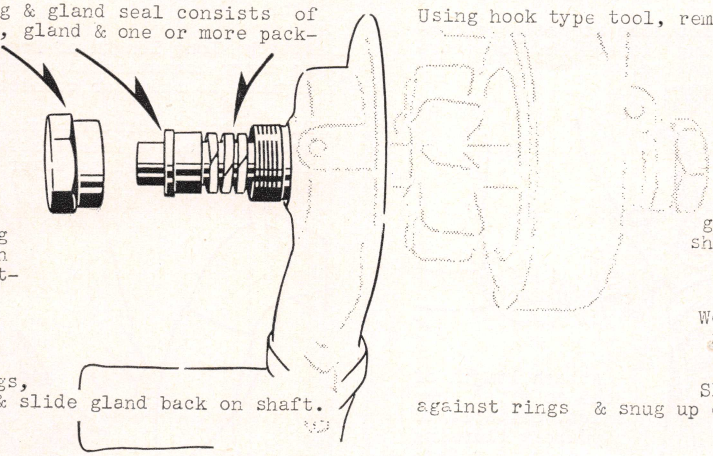
The flexible seal fits snug around the pump shaft, preventing water leakage at this point.

All seal parts are secured in pump impeller by means of a snap ring.

Arrangement of seal parts in impeller hub will differ in the various pump makes.

Consult engine manufacturers section of "Repair & Tune-Up Manual" for parts arrangement & installation information

WATER PUMP SEAL-PACKING RING & GLAND



Packing ring & gland seal consists of a gland nut, gland & one or more packing rings.

The packing rings are compressed between machined surfaces of pump housing & gland when nut is tightened.

To replace packing rings, remove nut & slide gland back on shaft.

Using hook type tool, remove old packing rings.

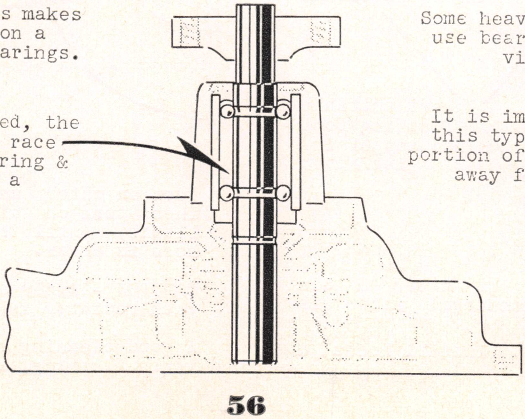
Examine shaft for wear at point of seal contact.

When deeply grooved, a new shaft should be used.

Work new rings into housing.

Slide gland up against rings & snug up on gland nut.

WATER PUMP-BALL BEARINGS



Water pumps of various makes have shaft supported on a double row of ball bearings.

On the pump illustrated, the shaft serves as inner race for bearings. The bearing & shaft are serviced as a unit & can not be replaced singly.

The assembly is lubricated & sealed when manufactured, requiring no further lubrication.

Some heavy duty engine pumps use bearings that are individually replaceable.

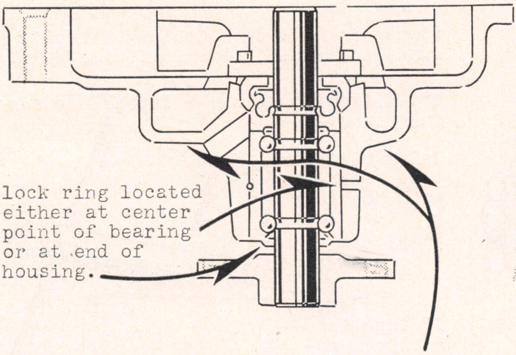
It is important to position this type bearing so sealed portion of rear bearing faces away from threaded end of shaft, & sealed side of front bearing faces threaded end of shaft.

Be certain slinger washer & bearing spacer are in position.

COOLING SYSTEM

WATER PUMP-OVERHAUL (BALL BEARING TYPE)

DISASSEMBLE:Shaft & bearing assemblies are retained in pump by means of wire

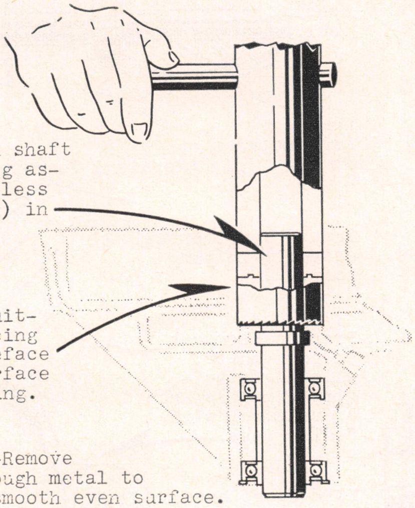


lock ring located either at center point of bearing or at end of housing.

Remove lock ring. Support pump housing at points where there are reinforcing webs inside pump body.

By exerting light arbor press pressure to impeller end of shaft, press shaft & bearing assembly out of impeller & housing.

CAUTION - Heavy pressure should not be necessary to remove assembly from pump housing.



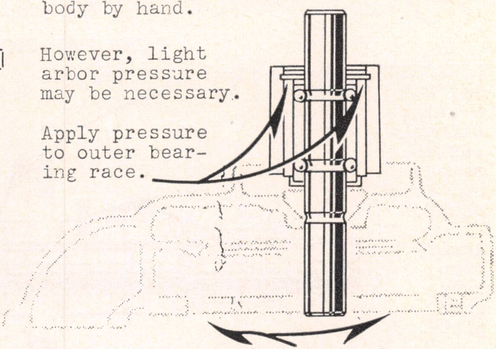
Position shaft & bearing assembly (less impeller) in housing.

Using suitable facing tool, reface seal surface of housing.

CAUTION-Remove only enough metal to obtain smooth even surface.

INSPECTION: Examine bearings, shaft & seal for wear & roughness. Replace parts as needed. Examine pump body for cracks & excessive rust deposites at cover gasket surface. Examine cover plate for uneven gasket surface. Be certain cover bolt hole threads are clean.

ASSEMBLE:Pump shaft & bearing assembly should normally enter & seat in pump body by hand.

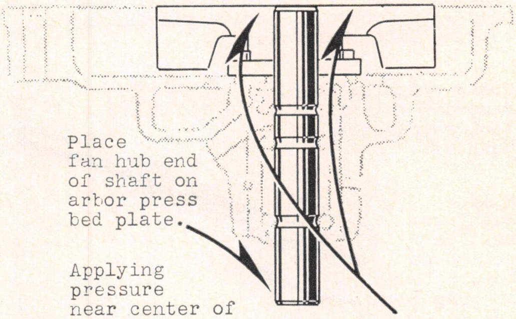


However, light arbor pressure may be necessary.

Apply pressure to outer bearing race.

CAUTION - Be certain pump body is supported evenly on cover surface when applying pressure.

With seal assembly positioned & locked in impeller hub, start impeller on end of shaft.

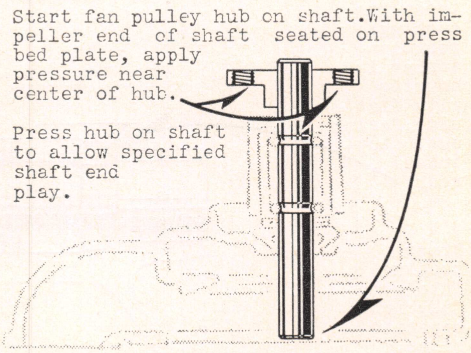


Place fan hub end of shaft on arbor press bed plate.

Applying pressure near center of impeller, press impeller onto shaft.

NOTE - Impeller must be properly positioned on the shaft. Consult "Repair & Tune-Up Manual" for correct positioning.

Start fan pulley hub on shaft.With impeller end of shaft seated on press bed plate, apply pressure near center of hub.



Press hub on shaft to allow specified shaft end play.

NOTE-Be certain end of shaft, not pump body, rests on bed plate.

COOLING SYSTEM

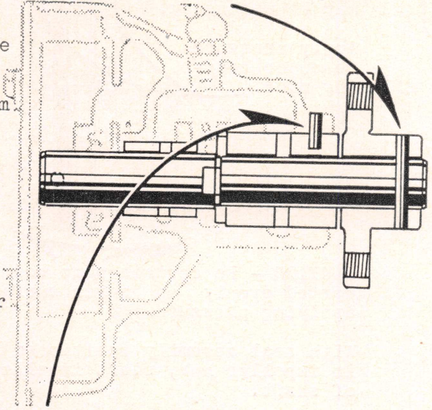
WATER PUMP (PLAIN BEARING TYPE)

Some water pumps employ plain bearings (Bushings) to support the pump shaft.

Bushings are press fit into pump body requiring burnishing after installing.

WATER PUMP-DISASSEMBLE-ASSEMBLE

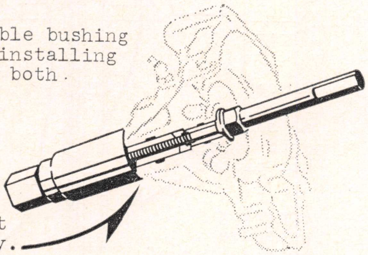
DISASSEMBLE: Drive pin out of fan pulley hub & using suitable puller, remove hub from shaft.



Remove pump body rear plate.

Slide impeller & shaft out of pump body.

If front bushing is retained in pump body with lock pin, drive pin through bushing into shaft hole.

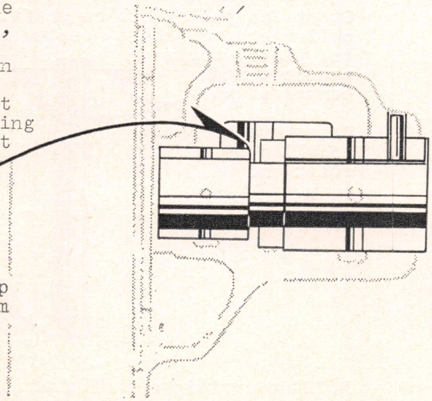


Using suitable bushing removing & installing tool remove both bushings.

NOTE-Bushings must be pulled out toward front of pump body.

Remove seal assembly from impeller. Examine all parts for wear or other damage.

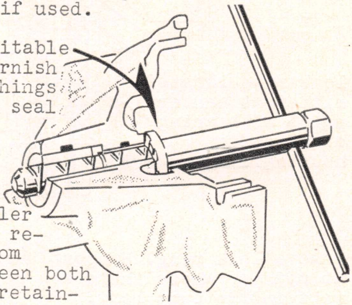
ASSEMBLE: If thrust washer is used between the bushings, position washer in housing with flat side facing out, slot toward rear.



Press bushings into pump body from opposite sides.

NOTE-Bushings must be accurately positioned in housing. Consult "Repair & Tune-Up Manual" for specific details.

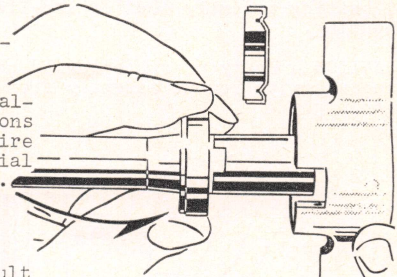
Drill front bushing & install retaining pin if used.



Using suitable tool, burnish both bushings & reface seal seat.

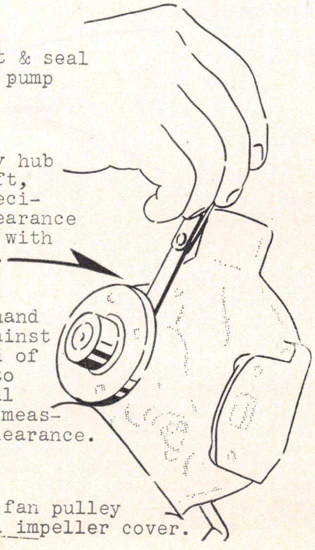
If impeller has been removed from shaft, peen both ends of retaining pin when impeller is reinstalled.

Assemble new seal parts in impeller hub.



NOTE-Some seal installations require special tool.

Consult manufactures section of "Repair & Tune-Up Manual.



Insert shaft & seal assembly in pump body.

Press pulley hub on pump shaft, allowing specified end clearance as measured with feeler gage.

NOTE-Exert hand pressure against impeller end of pump shaft to compress seal spring when measuring end clearance.

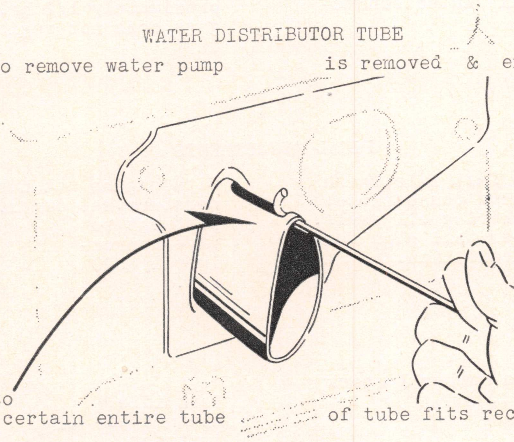
Install new fan pulley pin. Install impeller cover.

COOLING SYSTEM

WATER DISTRIBUTION

Some engines employ a water distributor tube to direct an even flow of water from pump against exhaust ports. This tube, running full length inside of water compartment of cylinder block is usually located behind water pump.

WATER DISTRIBUTOR TUBE



REMOVE: Necessary to remove water pump & radiator core to replace distributor tube.

On some engines water distributor tube is located behind welch plug near water pump.

Use suitable tool, such as a heavy rod with hook forged on one end to withdraw tube. Be certain entire tube is removed & engine water jacket is free of excess rust before installing new tube.

INSTALL: Slide new tube into cylinder block.

CAUTION-Do not force tube into cylinder block. If tube fits exceptionally tight, check for cause.

Be sure flared end of tube fits recess in cylinder block.

FAN & FAN BELT

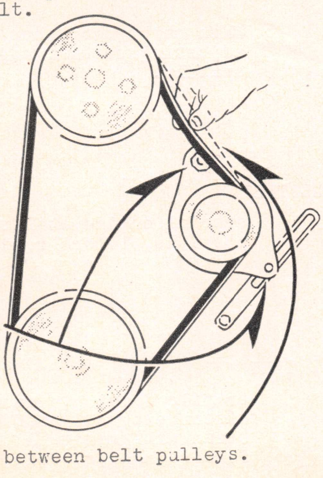
INSPECTION: Clean excessive accumulation of dirt from the fan blades & inspect for any cracked or bent blades. Straighten or replace parts as needed. Be certain the fan blades are securely fastened to hub. Inspect fan belt for cracked or worn material. Replace if necessary.

FAN BELT-ADJUSTMENT

Fan belt adjustment must allow a specified belt deflection, free movement, between pulleys.

When too little deflection is allowed, worn fan bearings, water pump bearings & generator bearings will result.

When too much deflection is allowed, worn fan belt, worn pulleys & engine heating will result.

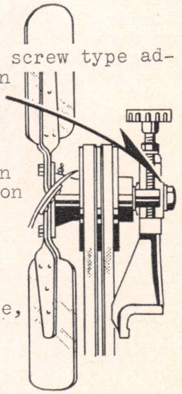


Belt deflection limits vary with manufacturers specifications.

This illustration shows the most common type of adjustment.

To adjust, loosen generator attaching bolts & clamp bolt.

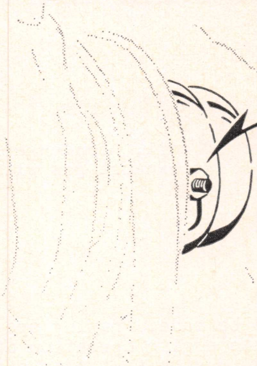
Move generator as needed to obtain correct belt deflection between belt pulleys.



To adjust fan belt when screw type adjustment is used, loosen lock nut at rear of fan shaft.

Move fan assembly up or down as needed to obtain specified belt deflection midway between pulleys.

Hold fan assembly & tighten lock nut.



To adjust split hub type, loosen two hexagon nuts on fan hub.

Turn front half of hub in direction of fan rotation to tighten belt to proper belt deflection between pulleys.

Tighten hexagon nuts.

FINAL CHECK

(AFTER MAJOR ENGINE REPAIR)

STARTING ENGINE

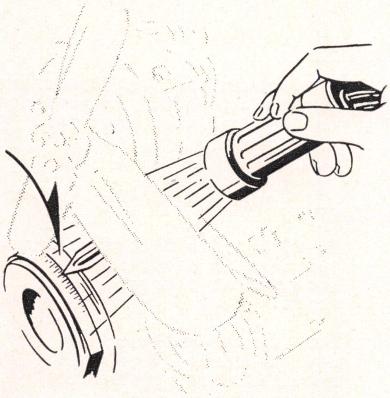
Before starting engine be sure the oil pan is filled to gage level with good grade engine oil of recommended weight Fill cooling system, adding anti-freeze if needed. Examine all water connections for leaks.

Start engine, keeping eye on oil pressure gage. Be sure gage registers pressure with first few engine revolutions Run engine at fast, not slow, idle approximately 1/2 hr. Be sure temperature gage does not register above 190° F.

FINAL ADJUSTMENTS

With engine running at fast idle, check for oil leaks at oil line connections; oil pan gaskets; main bearing oil seals. Check exhaust at muffler tail pipe for restricted or clogged condition.

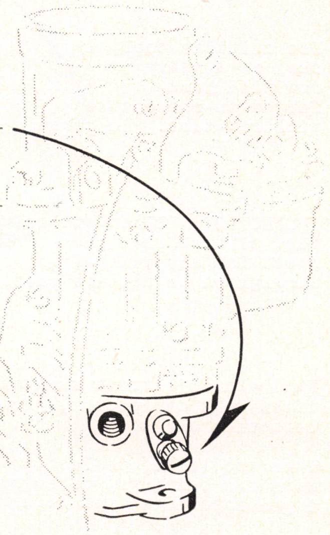
Connect timing-light to number 1 spark plug. With engine running at slow idle speed, set distributor timing to specified mark on vibration damper or flywheel.



Before removing timing-light from spark plug, vary engine speed to check operation of distributor automatic & vacuum controls.

With engine at normal operating temperature, set carburetor idle speed adjustment to give approximately 500 rpm.

Turn idle mixture adjustment screw in either direction until engine runs rough.



Then turn screw in opposite direction until smooth engine operation is obtained.

When carburetor has two idle mixture adjusting screws, adjust each one separately.

FINAL TEST

Make final tests of coil, condenser, manifold vacuum & the exhaust gas with special engine analizing equipment, if possible, before road testing.

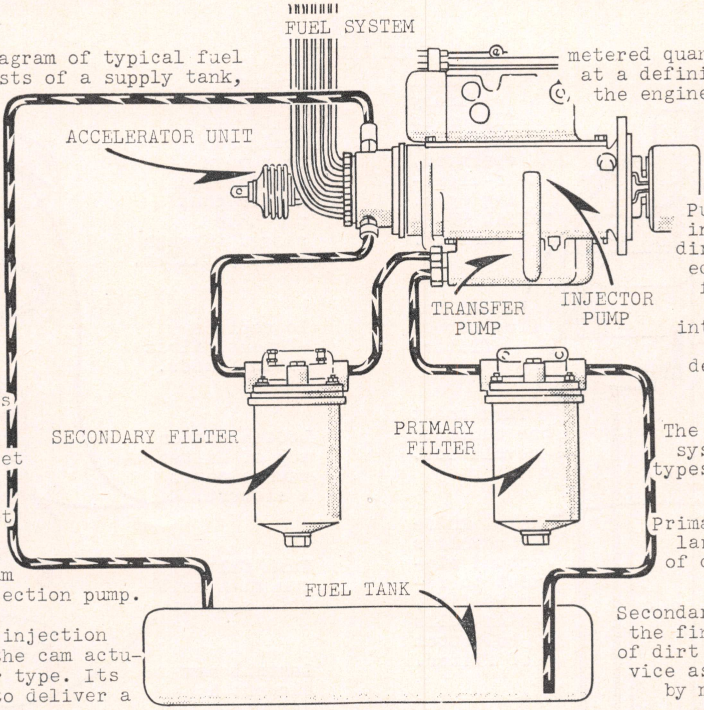
ROAD TEST

Road test should be made, paying special attention to engine operation at stops & starts. An engine that dies easily, or idles too fast for comfortable traffic driving, causes more customer discontent than most other complaints. Clean all grease & finger marks from fenders, hood, steering wheel, seats, etc.

DIESEL FUEL SYSTEM

Fuel used in diesel engines is distributed to cylinders under extreme high pressures by small pumps. These relatively small pumps must operate with very close tolerances.

It is obvious then that special care must be used to keep diesel fuel clean. Water, dirt & other substances in diesel fuel are the cause of majority of fuel system failures. "KEEP IT CLEAN".



Schematic diagram of typical fuel system consists of a supply tank, transfer pump, primary & secondary filters, fuel injection pump, fuel nozzles, governor & necessary fuel lines.

The typical transfer pump consists mainly of a housing with inlet & outlet connections, plunger & spring, inlet & outlet valve, actuated by a cam from the injection pump.

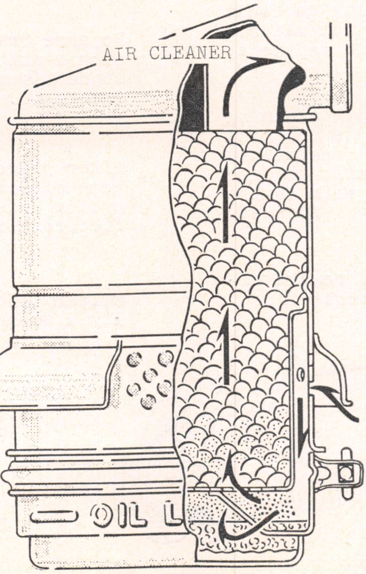
The typical injection pump is of the cam actuated plunger type. Its purpose is to deliver a metered quantity of fuel at a definite degree in the engine cycle under high pressure to the injector.

Purpose of the injector is to direct a metered quantity of fuel from injector pump. into combustion chamber in a definite spray pattern.

The typical fuel system uses two types of filters.

Primary; to remove large particles of dirt & water.

Secondary; to absorb the finer particles of dirt & dust. Service as recommended by manufacturer.



The air cleaner serves a double purpose by reducing noise of incoming air & removing dust & dirt which is main cause of engine wear.

Most common air cleaners are of the oil bath type & must be serviced according to operating conditions.

Dirt & dust is filtered out of air as it passes over an oil pool in bottom of filter & through a wire screen element located above oil pool.

Wash the wire screen in suitable solvent to remove oil & dirt.

Clean & refill oil cup to proper level. Never over fill.

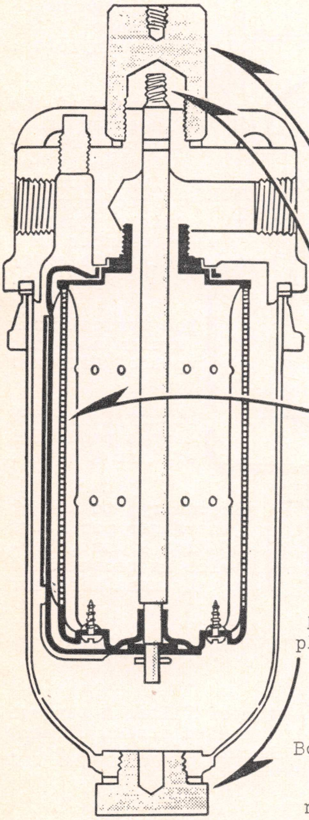
Service according to manufacturers instructions on side of air cleaner.

DIESEL FUEL SYSTEM

FUEL TANK

Clean fuel is most important for reliable performance in any diesel engine. Strain fuel through chamois to remove any dirt or water. Drain a small amount of fuel from the lowest point in the fuel tank once a week or oftener, if fuel bowl shows an accumulation of sediment.

FUEL FILTERS



Typical primary filter is manually operated, self-cleaning type, "METAL EDGE" variety.

Remove nut from top of filter.

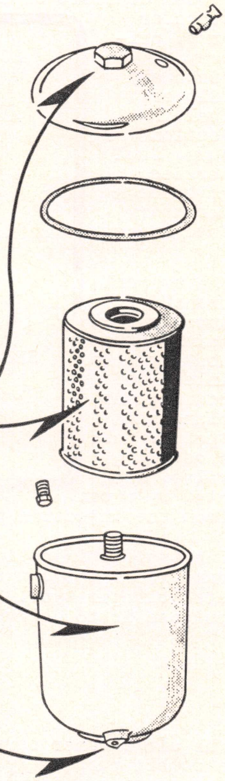
Turn shaft one complete revolution.

Metal knife revolves around element to remove dirt, which falls to bottom of filter.

Remove drain plug to clean out water & sediment.

Both cleaning & draining operations must be done with engine stopped.

In case of clogged element, remove element stack assembly & reverse flush. Tighten all connections.



Typical secondary filter is designed to remove any foreign matter that may have passed through primary filter.

To replace element, first drain filter.

Loosen nut on top of filter, remove cover & element.

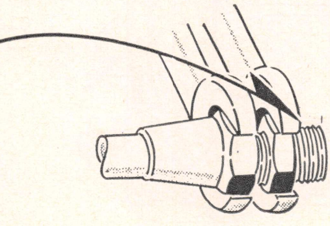
Wash filter can with suitable solvent.

Install new element & gaskets.

Be sure drain plug & all connections are tight.

After primary or secondary filter has been cleaned or lines removed, fuel system must be primed. Consult manufacturers recommendations.

Filter life is determined by the quality & amount of fuel consumed.



When possible, hold fittings with wrench while loosening or tightening tubing connections to prevent twisting.

Replace fuel lines that are cracked, bent or twisted out of shape, or connections with damaged threads.

Be sure replacement tubing & connections are of correct size & length.

DIESEL FUEL SYSTEM

FUEL INJECTION

Fuel injection into combustion chambers must be under extreme high pressure.Some manufacturers distribute the fuel to the injector nozzles under low pressure,creating the high pressure in mechanically operated injector nozzles.

Other manufacturers employ high pressure injector pumps, distributing the fuel to the nozzles under high pressure. Extreme care must be used when disconnecting or connecting fuel lines on either system.

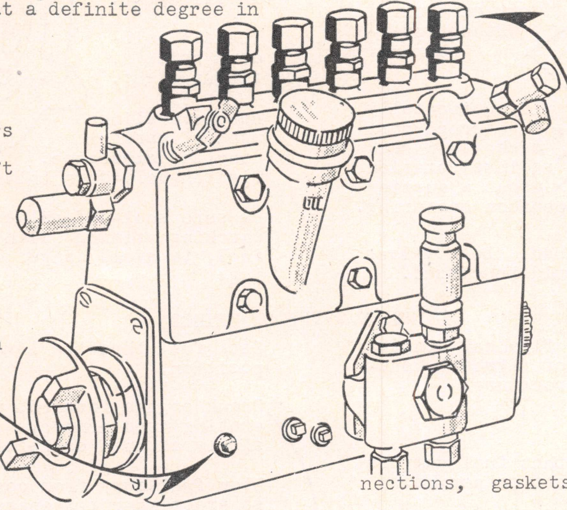
INJECTION PUMP

Typical injection pump is a constant stroke, cam-actuated, lapped-plunger type.

Injection pump function is to deliver metered fuel to spray nozzles under high pressure at a definite degree in engine cycle.

Be certain pump is at fault before removing.

Before loosening fuel lines, wash all surrounding parts with suitable solvent.



Pump is driven by chain or gears from engine camshaft at camshaft speed.

Lower part of pump housing contains lubricating oil which must be kept at proper level.

Upper part of pump housing contains fuel sump, delivery valve, spring & holder.

Dry with clean compressed air.

Hold fittings with wrench, while loosening tubing connections.

Protect open lines & connections with tape or caps.

With engine running, loosen fittings at nozzle holder, one at a time to determine if nozzle is faulty.

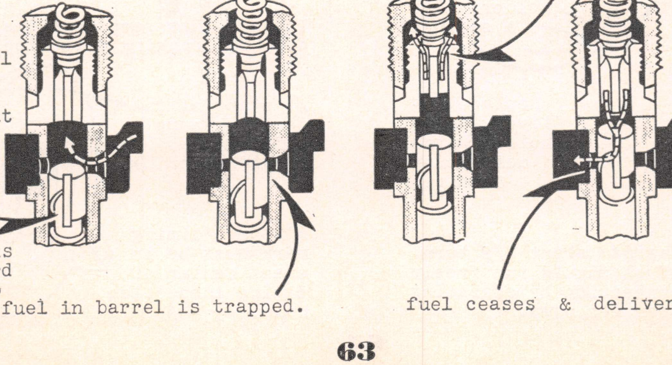
Be sure all connections, gaskets & valves are tight.

Again, observe cleanliness.

FUEL INJECTION CYCLE

Pump camshaft accuates each pumping element in accordance with firing order of engine.

Continued upward movement of plunger forces fuel to open spring-loaded delivery valve.



Each pumping element receives fuel from supply sump, when plunger is at bottom of stroke.

As plunger is forced upward past the two open ports, fuel in barrel is trapped.

Fuel is then delivered into pipe leading to nozzle, producing a fuel discharge into combustion chamber.

Instant that by-pass helix uncovers by-pass port, delivery of fuel ceases & delivery valve closes.

DIESEL FUEL SYSTEM

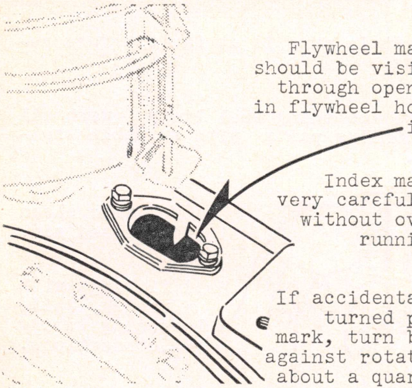
INJECTION PUMP TIMING

Manufacturers employ various methods of timing & location of timing marks. Refer to manufacturers instructions.

No other adjustments are more critical than injection pump timing. Consult manufacturers instructions.

TYPICAL PROCEDURES

Rotate engine in normal running direction until No. 1 piston is approaching top center on compression stroke.



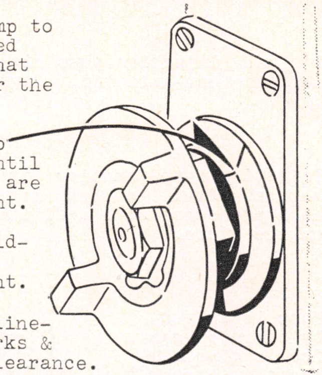
Flywheel marks should be visible through opening in flywheel housing.

Index marks very carefully, without over-running.

If accidentally turned past mark, turn back against rotation about a quarter turn & try again for perfect centering.

With timing marks alined, both valves of No. 1 cylinder should be closed.

If not true, the engine is 360° out of time & must be rotated one full turn.



Examine pump to be installed for dirt that might enter the system.

Rotate pump coupling until both marks are in alinement.

Install hold-down bolts finger tight.

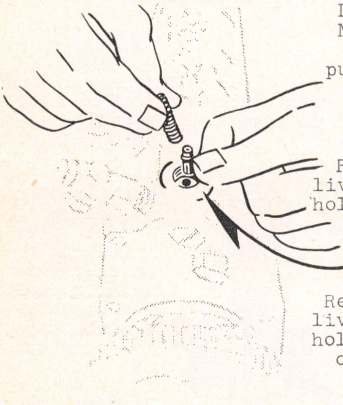
Re-check alinement of marks & coupling clearance. Tighten hold-down bolts & lock screws.

Be sure shut-off valve is closed, when checking timing with system full of fuel, to avoid danger of engine starting.

TIMING BY OVERFLOW METHOD

Crank engine until flywheel timing mark centers in hole of flywheel housing. Refer to above procedure.

"Port closing" means that fuel pump is timed at start of injection period.



Disconnect No. 1 fuel line at pump & nozzle.

Remove delivery valve holder, valve & spring.

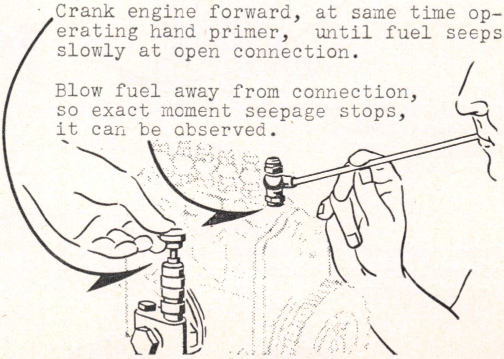
Replace delivery valve holder without spring & valve.

Turn engine backwards about 1/2 turn. At this point, fuel should run freely from the No. 1 connection by operating hand primer on transfer pump.

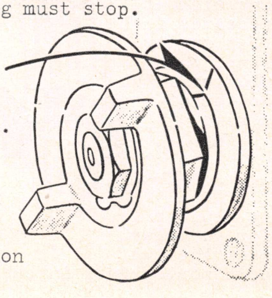
Set fuel throttle lever in full open position.

Crank engine forward, at same time operating hand primer, until fuel seeps slowly at open connection.

Blow fuel away from connection, so exact moment seepage stops, it can be observed.



Instant that seepage stops, injection begins, cranking must stop.



At start of injection, pump timing marks should coincide.

Flywheel timing mark must be in exact center of timing inspection hole.

DIESEL FUEL SYSTEM

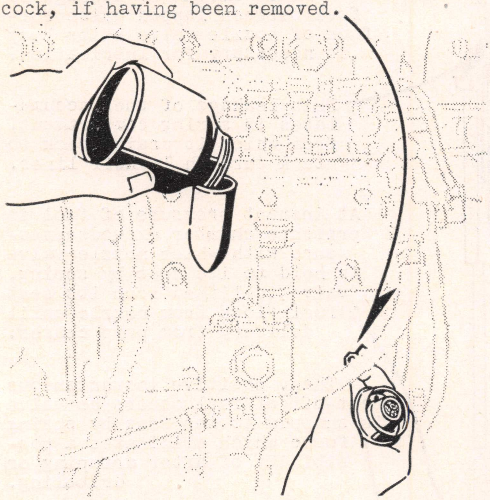
PRIMING FUEL SYSTEM

Ordinarily, there are two steps to be taken to remove air from low pressure system, consisting of secondary filter & injection pump.

After servicing or replacing any parts directly connected with fuel injection, it will be necessary to prime the fuel system.

HIGH & LOW PRESSURE

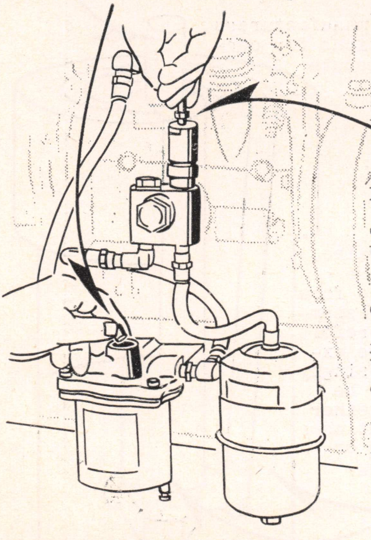
Fill the bottom of fuel injection pump with lubricating oil up to oil level cock, if having been removed.



Be certain the governor is filled with lubricating oil to overflow level.

Fill primary & secondary filters with clean fuel oil.

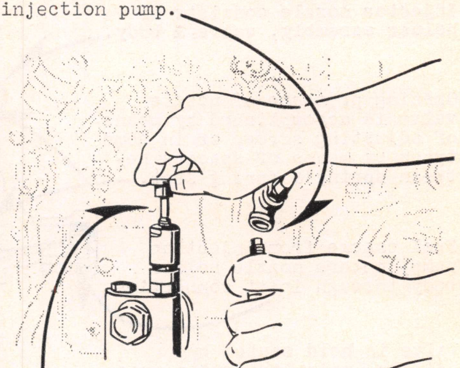
Loosen vent screw at top of secondary filter.



Turn top of hand primer pump to left & operate until a solid stream of fuel flows free of bubbles & foam.

Close secondary vent screw, while continuing to operate hand primer pump, to keep air from entering fuel system.

Next, open overflow line at top of fuel injection pump.



Operate the hand primer until a steady stream of fuel flows from vent.

When certain, low pressure system is void of air, tighten the bleeder screw while continuing to operate pump.

It may, or may not be necessary to prime high pressure system, if only small amount of fuel is lost when servicing nozzles.

If engine has been idle for some time or out of fuel, priming will be necessary.

Loosen the connection at each injector (about one turn) to permit air to escape under pressure.

Be sure not to loosen connector too far, permitting excessive amount of fuel spraying over engine.

With the fuel throttle control in full load position, turn engine over several times with starter to purge the lines. Tighten all connections.

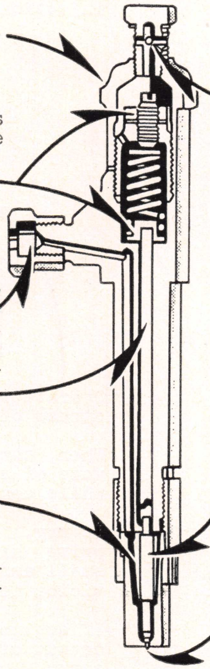
DIESEL FUEL SYSTEM

FUEL INJECTORS

Function of typical injector is to direct a metered amount of fuel received from injection pump into combustion chamber in a definite spray pattern.

Injectors use a spring loaded valve with seat near spray orifice. Valve is hydraulically operated by pressure of fuel delivered by injection pump.

TYPICAL INJECTOR



Injector nozzle consists of holder assembly, valve & body.

Opening pressure of nozzle valve is accomplished by means of adjusting screw, or in some types by means of spacers between spring & spring seat.

Fuel charge from injection pump, enters nozzle holder body through inlet connection.

Valve is held seated by spindle, which transmits pressure of adjusting spring.

Fuel passes through drilled passages of nozzle body & into pressure chamber.

Nozzle holder body is used to hold nozzle in its correct position in cylinder head & provides a means of conducting fuel to nozzle.

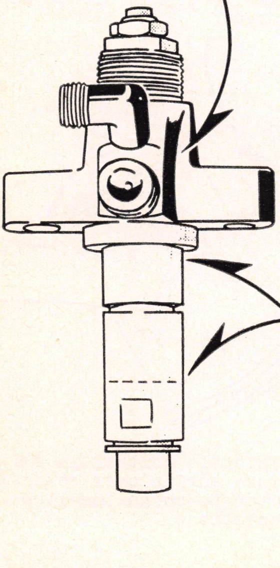
Small amount of seepage of fuel between lapped guide surface of nozzle valve & its body is necessary for lubrication.

This leakage of fuel accumulates in spring compartment, from which it drains back to tank through leakoff lines.

At instant pressure of fuel in pressure chamber exceeds pressure with which nozzle valve is held to its seat by spring, valve is lifted from its seat & fuel flows from nozzle until delivery from pump ceases.

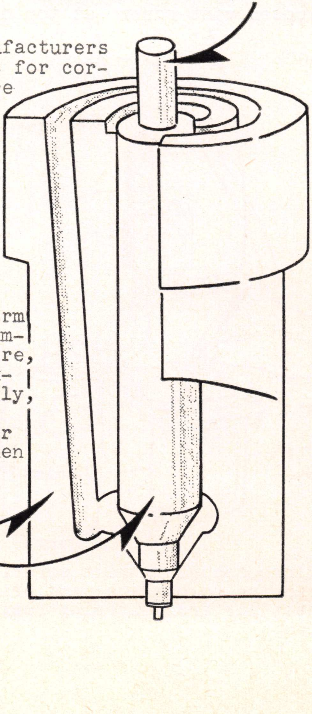
Then, positive instantaneous cut-off of fuel occurs as valve is snapped to its seat by spring force which eliminates a possibility of after dripping or dribbling.

Upper end of nozzle valve has an extension of reduced diameter, referred to as stem, which makes contact with lower end of spring loaded spindle.



Lower end of body is provided with an accurately ground & lapped surface which makes a leak proof & pressure tight seal with corresponding lapped surface at upper end of nozzle.

Consult manufacturers instructions for correct pressure setting.



Nozzle valve & body are lapped to form a mated assembly. Therefore, cannot be exchanged singly, but must be kept together as a unit when cleaning or servicing.

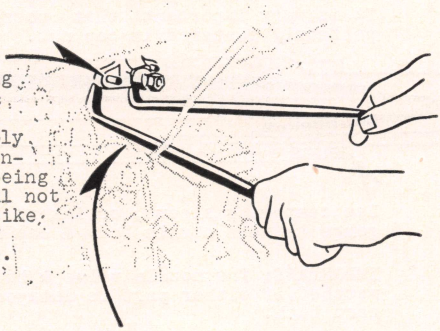
Cleanliness cannot be over-emphasized.

DIESEL FUEL SYSTEM

INJECTOR-REMOVE & INSTALL

Before loosening fuel lines, wash nozzle & surrounding parts of engine with suitable solvent & dry with clean compressed air.

Wrap open ends of lines with tape or caps to prevent entry of dirt.

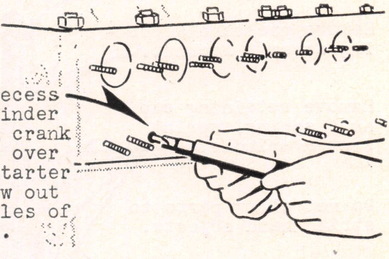


Remove holding nuts & pull assembly from engine being careful not to strike end of nozzle.

It may be necessary to use suitable puller to break nozzle loose from carbon.

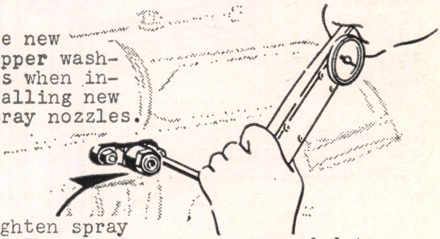
Use extreme caution to avoid dropping dirt into injector opening.

Remove all carbon & dirt from holder recess before installing nozzle.



Ream recess in cylinder head & crank engine over with starter to blow out particles of carbon.

Inspect recess visually for complete carbon removal & smooth shoulder face.

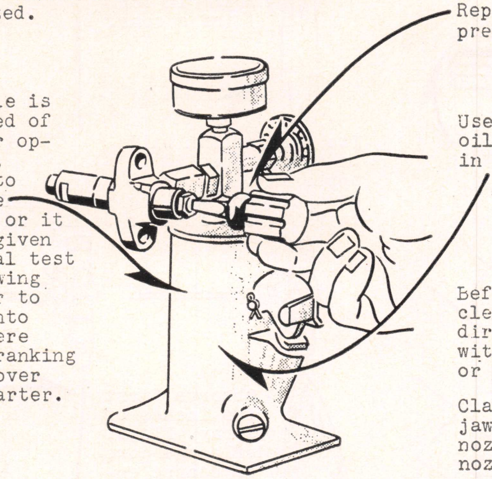


Use new copper washers when installing new spray nozzles.

Tighten spray nozzles evenly & to recommended torque.

INJECTOR-INSPECTION & TESTING

Injectors & nozzles are manufactured to precision accuracy. Therefore, necessity for cleanliness can not be overemphasized.



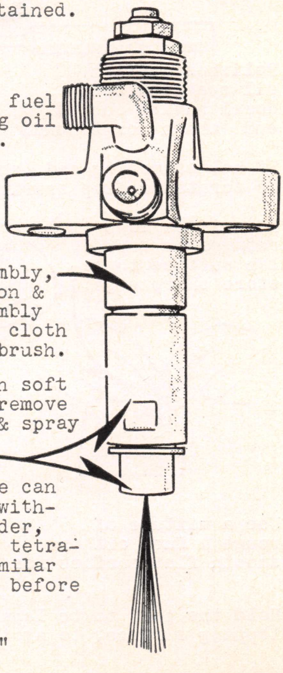
If nozzle is suspected of improper operation, attach to suitable tester, or it may be given a general test by allowing injector to spray into atmosphere while cranking engine over with starter.

CAUTION: Keep hands away from nozzle spray at all times.

Test injectors or nozzles for leakage, valve opening pressure & spray pattern. Consult manufacturers specifications for opening pressure.

Remove nozzle protecting cap & loosen adjusting screw locknut.

Repeat adjustments & test until proper pressure is obtained.



Use only clean fuel oil or flushing oil in tester tank.

Before disassembly, clean all carbon & dirt from assembly with lint free cloth or brass wire brush.

Clamp holder in soft jawed vise to remove nozzle holder & spray nozzle.

If nozzle valve can not be easily withdrawn from holder, soak in carbon tetrachloride or similar carbon solvent before removal.

"KEEP IT CLEAN"

DIESEL FUEL SYSTEM

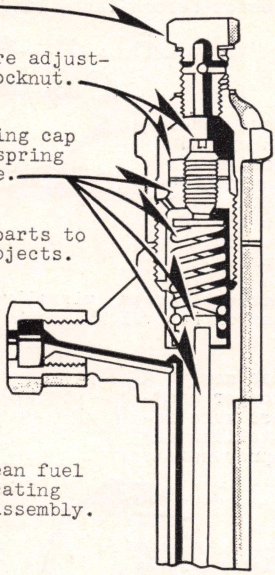
INJECTORS-INSPECTION & CLEANING

Invert nozzle holder & remove protection cap.

Remove pressure adjusting screw & locknut.

Remove retaining cap nut, spring, spring seat & spindle.

Do not allow parts to strike hard objects.

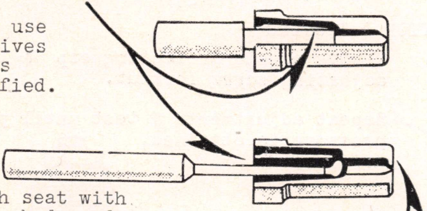


Provide pan of clean, non-corrosive cleaning solvent.

Use pan of clean fuel oil for lubricating parts during assembly.

Use only brass scrapers to remove carbon from pressure chamber & body seat.

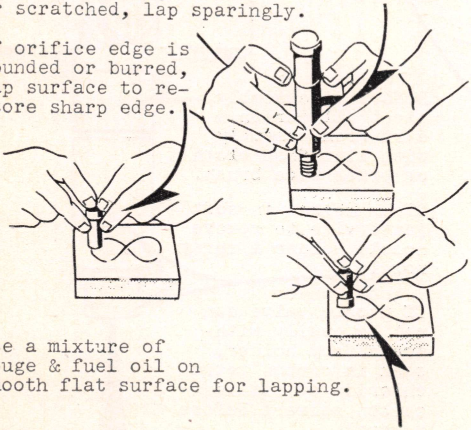
Never use abrasives unless specified.



Polish seat with oil soaked wooden dowel having conical end which corresponds to seat angle.

If holder mating end should be burred or scratched, lap sparingly.

If orifice edge is rounded or burred, lap surface to restore sharp edge.



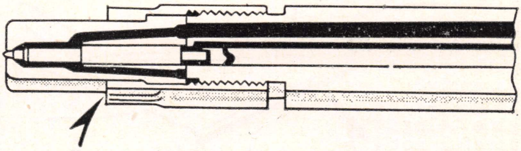
Use a mixture of rouge & fuel oil on smooth flat surface for lapping.

Hold the part to be lapped low or near lapping surface, to avoid cocking.

Wash valve & body, blow dry with compressed air. Then, dip parts in clean fuel oil & assemble.

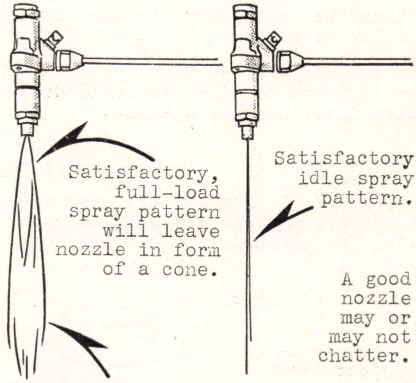
To test for sliding fit, pull valve partly out of body. Holding at 45° angle, let valve slide into body. If valve sticks, apply tallow, work until free.

It is very important that nozzle be perfectly centered in cap nut.



Use centering sleeve, or insert feeler gauge between nozzle body & cap nut.

IMPORTANT: The nozzle valve & body are matched, if either part is damaged, discard both.

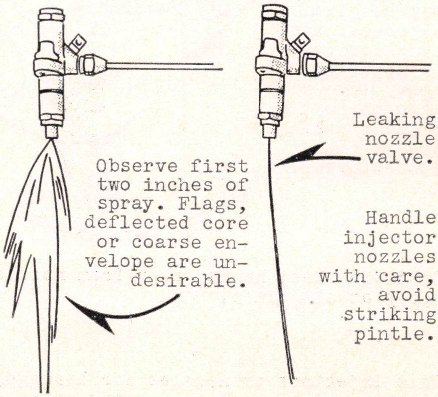


Satisfactory, full-load spray pattern will leave nozzle in form of a cone.

Satisfactory idle spray pattern.

A good nozzle may or may not chatter.

Its termination will be clean, & solid appearing. Center core of cone will be surrounded by fog in which all fuel is evenly atomized.



Observe first two inches of spray. Flags, deflected core or coarse envelope are undesirable.

Leaking nozzle valve.

Handle injector nozzles with care, avoid striking pintle.

When storing or shipping, protect against moisture to prevent corrosion.

DIESEL FUEL SYSTEM

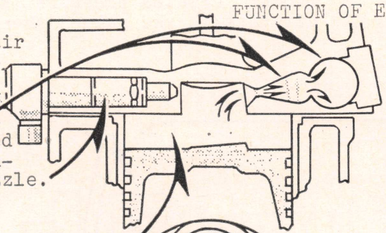
ENERGY CELL

Typical type energy cell, one in each cylinder head, located directly opposite the injection nozzle. Its primary function is to increase turbulence & control combustion.

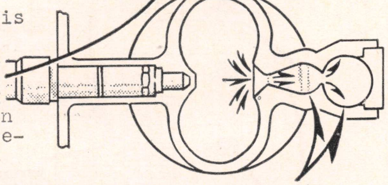
At injection, cylindrical combustion chamber directly below exhaust valve consentrates air around fuel spray & produces a swirl that creates a uniform mixture.

FUNCTION OF ENERGY CELL

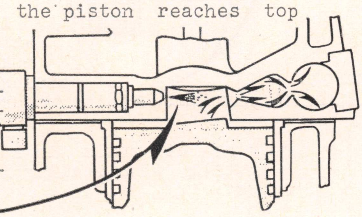
This type air cell is divided into a major & minor chamber, located opposite injection nozzle.



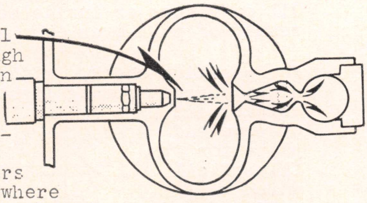
While air is being compressed in main chamber during compression stroke, predetermined amount is forced into minor & major energy cell.



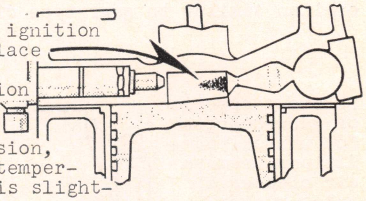
Just before the piston reaches top dead center, while air is being forced through opening into auxiliary chambers at high velocity, injection of fuel begins.



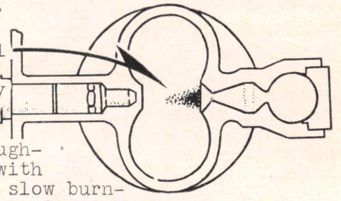
Atomized fuel passes through heated air in main combustion chamber & a predetermined amount of fuel enters energy cell where it is mixed with this inrushing air.



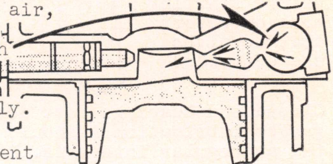
Initial ignition takes place in main combustion chamber where compression, & also temperature, is slightly higher.



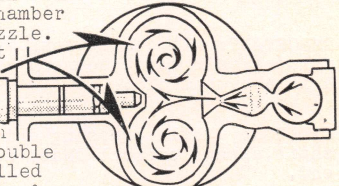
Here, fuel mixture burns very slowly as it is not yet thoroughly mixed with air. This slow burning of fuel eliminates sudden shock to piston, rod & bearings.



In auxiliary chambers where fuel is mixed with air, burning is rapid, high pressure is developed quickly.



Blast is sent across main combustion chamber toward nozzle. This blast breaks up fuel in front of cell which starts "Double Swirl" called turbulence, & results in complete combustion of fuel.

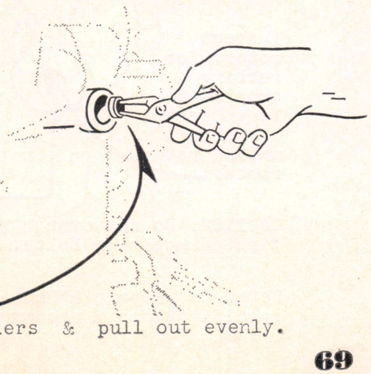


ENERGY CELL-REMOVE & INSTALL

Carbon may form in energy cells, therefore, it is recommended they be removed occasionly for cleaning & inspection.

Remove air cell cover clamp or plug.

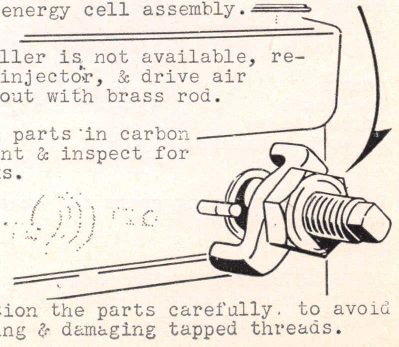
Grip energy cell cap with thin nosed pliers & pull out evenly.



Using suitable screw type puller, remove energy cell assembly.

If puller is not available, remove injector, & drive air cell out with brass rod.

Clean parts in carbon solvent & inspect for cracks.



Position the parts carefully to avoid cocking & damaging tapped threads.

DIESEL FUEL SYSTEM

SUPERCHARGER

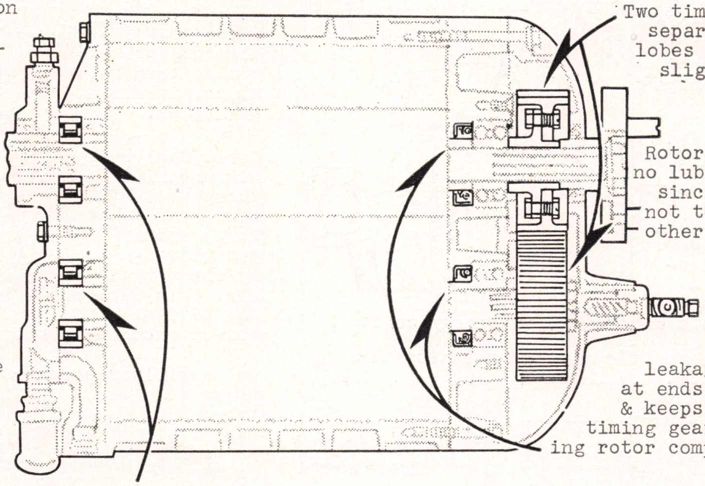
Typical positive displacement supercharger, belt or gear driven, designed chiefly for efficient diesel operation, supplies air needed for combustion.

Two rotors revolve with close clearances in housing mounted on engine. Operation similar to gear type oil pump.

Air is drawn into supercharger from air cleaner, where it is picked up by lobes & carried to discharge side, & through pipe to intake manifold.

This continuous discharge of air from blower creates pressure which forces air past intake valves when opened.

ROTOR TYPE



Before inspection of supercharger for unusual conditions, remove air cleaner & inlet system.

With rotors exposed, engine running, keep fingers, clothing & all loose parts away from inlet.

CAUTION: Render starting equipment inoperative before starting work on rotors that involves use of hands.

Two timing gears separate rotor lobes with very slight clearance.

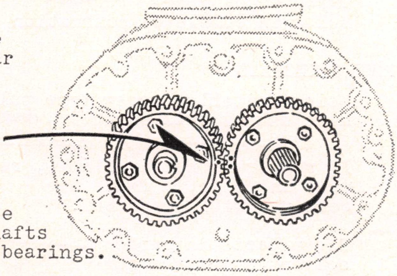
Rotors require no lubrication, since they do not touch each other or housing.

Oil seals prevent leakage of air at ends of lobes & keeps oil from timing gears entering rotor compartment.

Closed end bearings are designed for grease lubrication & should be inspected at regular intervals. Refer to lubrication chart.

IMPORTANT: All connections must be absolutely air tight between air cleaner & intake manifold.

CAUTION: While pressing drive gear on shaft, always support shaft at opposite end.



Assemble idle gear with timing marks in line.

Check for loose rotor shafts or worn bearings.

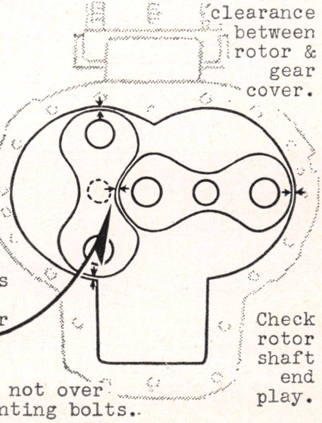
Inspect the timing gears for excessive back-lash.

IMPORTANT: Inlet system should be carefully cleaned before placing supercharger in operation.

Soak new oil seals in lubricating oil & install with sealing lip away from rotor.

Oil on rotors or inside housing may be result of pull-over from air cleaner.

For positive check, with engine running, direct strong light into rotor compartment & observe end plate for film of oil which will radiate away from leaky seal.



Check clearance between rotor & gear cover.

Inspect rotors for rubbing & scoring between crowns of lobes & mating rotor roots.

Check rotor shaft end play.

CAUTION: Do not over tighten mounting bolts.

Refer to Repair & Tune-Up Manual for specifications & recommended torques.

Thompson

SHOP-WAYS MANUAL

FRONT WHEEL SUSPENSION

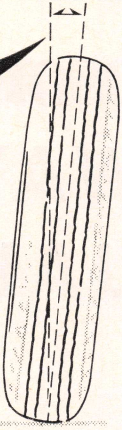
SECTION

FRONT END ALINEMENT

Proper front wheel alinement is essential to assure ease of steering & to prevent excessive front tire wear. Five important angles must be considered. Camber angle; Caster angle; Pivot pin inclination angle; Toe-in; Toe-out. After correcting any one angle re-check all other angles.

FIVE IMPORTANT ANGLES

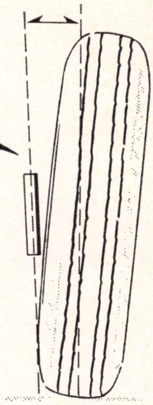
CAMBER ANGLE is angle of front wheel tilt from the vertical as viewed from front.



Outward tilt at top is positive camber; inward tilt at top is negative camber.

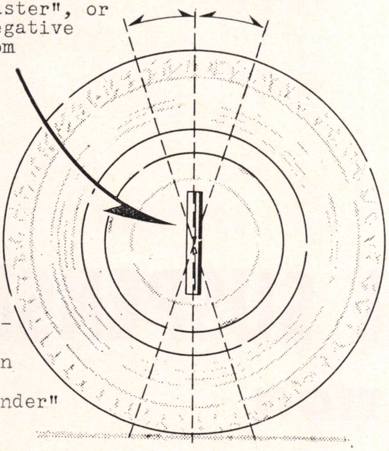
NOTE-Front wheels must be pointed straight ahead when measuring camber angle, to prevent false readings caused by pivot pin inclination angle.

PIVOT PIN INCLINATION is the angle that the top of pivot pin tilts from vertical as viewed from front.



This angle works hand in hand with "Camber Angle" & "Caster Angle" to keep vehicle steady, tracking straight ahead & reducing strain when turns are negotiated.

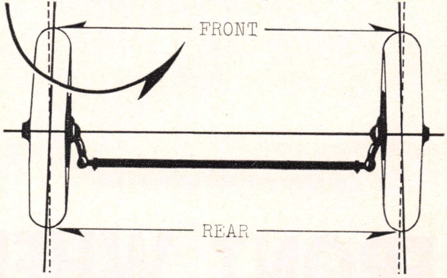
CASTER ANGLE is the angle that the top of pivot pin tilts backward, "Positive Caster", or forward, "Negative Caster", from vertical as viewed from the side.



Positive caster creates a desirable "Following Action".

Negative caster usually results in an undesirable "Steering Wander" condition.

TOE-IN is the setting or adjusting of front wheels so distance between front of wheels is less than the distance at rear as viewed from top.



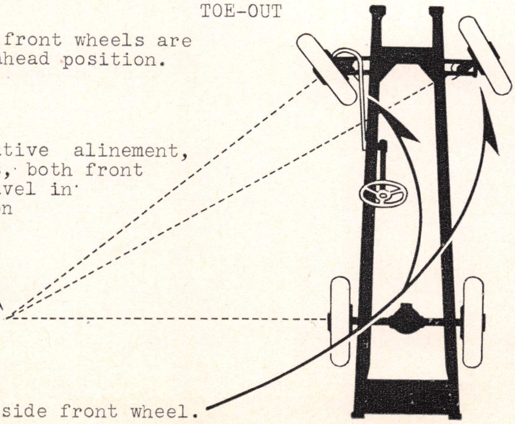
Excessive toe-in will result in abnormal tire wear.

Insufficient toe-in may result in "Road Wander".

TOE-OUT

Toe-out occures when front wheels are turned from straight ahead position.

To be in correct relative alinement, when negotiating turns, both front & rear wheels must travel in circles having a common center.



The inside front wheel travels in a circle having a smaller arc than circle traveled by outside front wheel.

Amount of toe-out depends on how far wheels are turned away from center; length of vehicle wheelbase; distance between steering knuckles.

Toe-in of front wheels is changed to toe-out by offset construction of the steering knuckle arms.

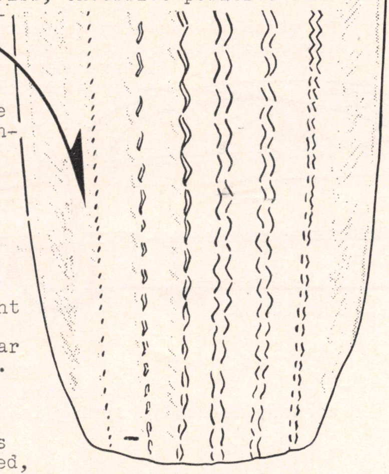
FRONT END ALINEMENT

Front end alinement correction operations are usually performed to stop one of the following conditions. Excessive tire wear or erratic steering.

Prior to starting test or repair operations it is good practice to examine front tires for clues pointing to causes of difficulty.

FRONT TIRE VISUAL INSPECTION

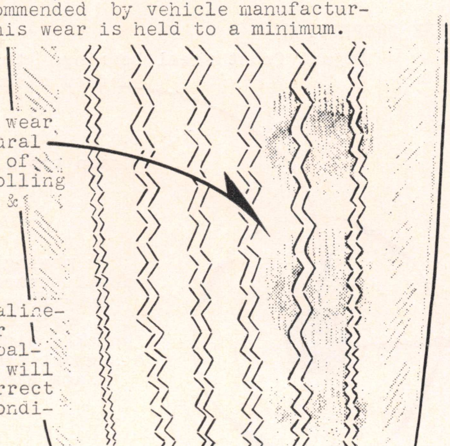
When front tire shows noticeable wear on outer ribs, excessive positive camber is indicated.



Noticeable wear on inside ribs indicates excessive negative camber.

NOTE-Slight positive camber wear is normal.

When tires are rotated, as recommended by vehicle manufacturers, this wear is held to a minimum.

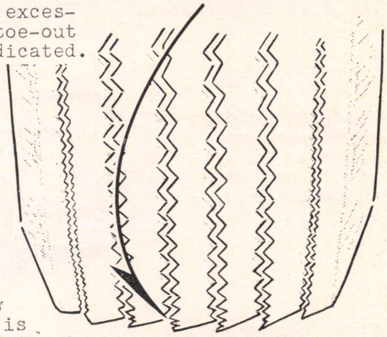


Spotty wear is natural result of free rolling wheels & tires.

Wheel alinement or wheel balancing will not correct this condition.

Rotation of tires as recommended by vehicle manufacturers is best method of control.

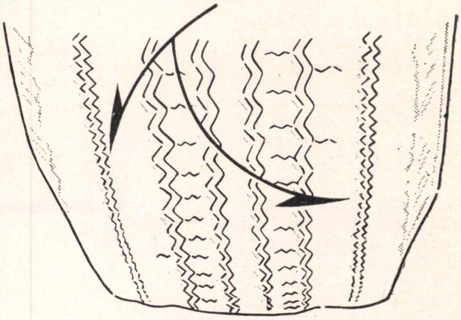
Saw tooth wear on front tire rib is an indication of incorrect toe-in or toe-out adjustment. When high side of saw tooth wear is on outside of tire ribs, excessive toe-out is indicated.



When high side of saw tooth is on inside of tire ribs, excessive toe-in is indicated.

Under inflation & over inflation are also causes of excessive tire wear.

Excessive wear on the two ribs adjacent to the outer & inner shoulder ribs indicates under inflation.



Excessive wear at center of tread indicates over inflation.

Worn pivot pins, wheel wobble, unequal brakes, high speed on turns & sustained high speed driving also contribute to excessive front tire wear.

WHEEL BALANCE

Out of balance wheels are responsible for many steering difficulties & tire wear complaints. Wheel bounce & steering shimmy at speeds above 35 mph. often results. Bent or wobbly wheels also contribute to excessive tire wear.

FRONT END ALINEMENT

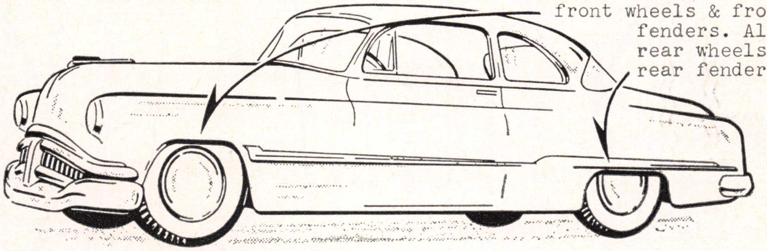
GENERAL INSPECTION OPERATIONS

Several factors, closely related to front end alinement, must be inspected prior to making front end alinement tests. A successful alinement job cannot be accomplished until these inspection operations are accomplished.

CAR HEIGHT INSPECTION

Inflate all tires to recommended pressure. Be certain vehicle is under "CURB LOAD", with full capacity of oil, water, gasoline, spare wheel & tire in place, but free of passengers or luggage.

Place vehicle on level spot on floor or on special front end alinement equipment rack.



Grasp center of front bumper & bounce vehicle. Allow car to settle to place springs & shock absorbers in normal free position.

By visual inspection determine approximate condition of springs. Notice relative distance between front wheels & front fenders. Also rear wheels & rear fenders.

When vehicle looks low at one corner, defective spring is indicated.

WHEEL & TIRE INSPECTION

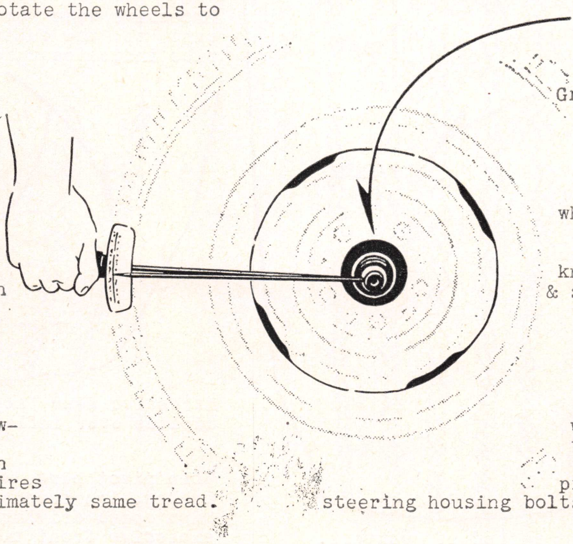
Raise front end of car so front wheels are free to turn. Rotate the wheels to check for run-out (wobble).

A slight wobble of 1/8" is considered permissable.

Rotate front wheels slowly to check for brake shoe drag & wheel balance.

Wheels should come to smooth stop. When wheel stops, then rotates in opposite direction, out of balance condition is indicated.

Check tires for blowout patches, vulcanized repairs & thin tread. Both front tires should have approximately same tread.



Adjust front wheel bearings to specified clearances.

Grasp top & bottom of wheel.

By moving top of wheel toward, then away from frame, worn steering knuckle pivot pins & support arm bushings can be detected.

By rocking front wheels from front to rear, worn tie rod ends, loose pitman arm & loose steering housing bolts can be detected.

RESULT OF GENERAL INSPECTION

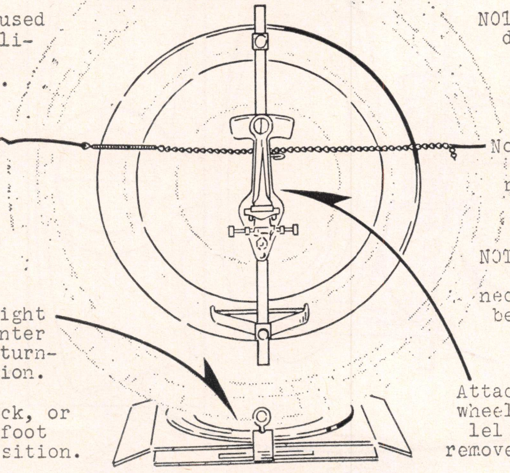
When general inspection reveals worn or defective front suspension parts, steering gear assembly, tie rod ends, steering knuckle pivot pins or bushings, defective springs, tires or brakes, corrective measures must be taken to put all in proper order before correct front end alinement can be obtained.

FRONT END ALINEMENT

ALINEMENT TESTS

Alinement test procedures & methods are the same on all types of front suspension. Special equipment is required. Test equipment, gages & test procedures used in the following text are but one of many popular types. Follow instructions furnished by equipment manufacturers for best results.

STEERING KNUCKLE ANGLE TESTS



One set of gages is used to test king pin inclination angle, camber angle & caster angle.

Once the gages are attached, all three angles are tested & adjusted without change of gage positioning on wheels.

With all tires inflated to recommended pressure, place front wheels in straight ahead position in center of turntables. Lock turntables in zero position.

Using brake pedal jack, or suitable tool, lock foot brakes in applied position.

NOTE-Keep brakes applied during king pin inclination angle, camber angle & caster angle tests & adjustments.

Normalize front springs & shock absorbers by rocking car & allowing it to come to rest.

NOTE-Normalizing springs & shock absorbers is necessary after door has been opened & closed to apply foot brakes.

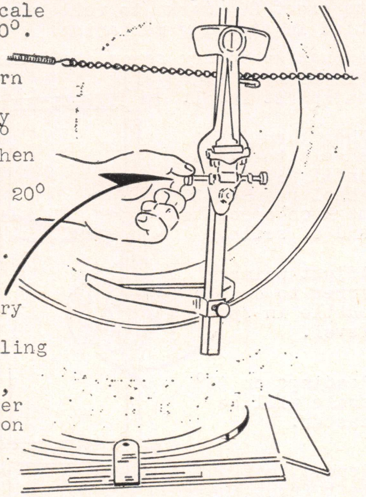
Attach gage to right front wheel with quadrant parallel with the wheel. Then remove turntable lock pins.

KING PIN INCLINATION

King pin inclination is the number of degrees top of king pins incline, away from true vertical, toward the vehicle. This inclination imparts a tendency to return front wheels to straight-ahead position after they have been turned.

KING PIN INCLINATION TESTS

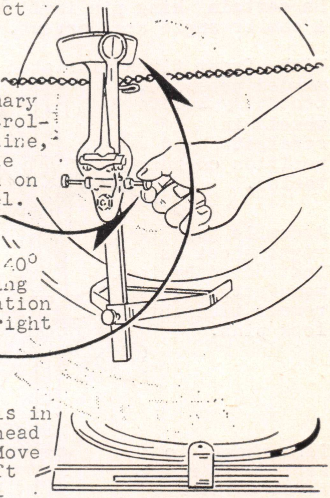
With gage on right wheel, turn front wheels to left until right wheel turntable scale reads 20°.



NOTE-Turn wheels slightly past 20° mark, then back to exactly 20° mark to relieve strains.

Adjust secondary screw, controlling short pointer, to center bubble on spirit level.

Then turn wheels to right until right turntable has turned slightly past 20° mark on opposite end of scale, then back to exact 20° mark.



Adjust primary screw, controlling hair line, until bubble is centered on spirit level.

Reading on 40° scale is king pin inclination angle for right wheel.

Place wheels in straight-ahead position. Move gage to left front wheel & repeat test for left wheel angle.

RESULT OF TEST

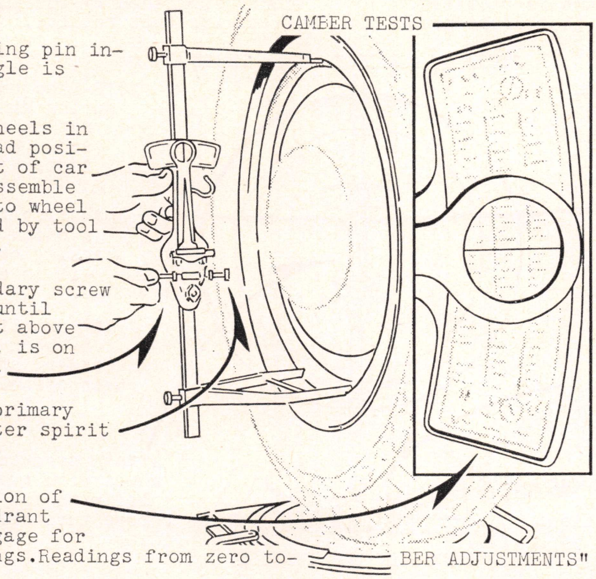
When king pin inclination is found to be other than specified limits, a bent frame, bent steering knuckle support or bent control arm are indicated. Frame must be straightened, or bent parts replaced with new ones as required, before true camber & caster angle readings can be obtained.

FRONT END ALINEMENT

CAMBER

Camber is the degree of outward,or inward tilt of the wheel at the top.Camber imparts a tendency to support most of car weight on wheel inner bearing.

CAMBER TESTS



Be certain king pin inclination angle is correct.

With front wheels in straight-ahead position & weight of car on wheels, assemble camber gage to wheel as instructed by tool manufacturer.

Adjust secondary screw on quadrant until pointer, just above spirit level, is on scratch mark.

Then adjust primary screw to center spirit level bubble.

Use 60° section of scale on quadrant assembly of gage for camber readings.Readings from zero toward wheel indicate positive camber. Readings from zero away from wheel indicate reverse camber.

NOTE- When wheel is known to be slightly untrue, turn wheel 180° & recheck camber. Use an average of the two readings for the true camber angle.

Make camber test on opposite wheel in same manner.

Adjust camber as outlined in "CAMBER ADJUSTMENTS" section if necessary.

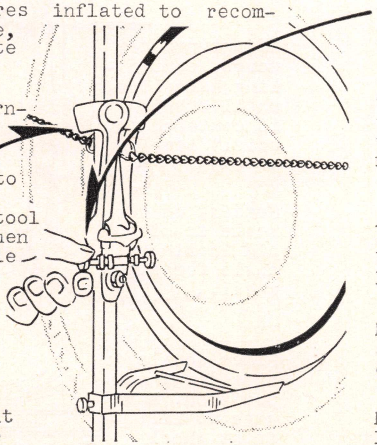
CASTER

Caster is the degree of backward, or forward tilt of the king pin from the true vertical.

Caster assists the "King Pin Inclination" to return & hold front wheels in straight-ahead position.

CASTER TESTS

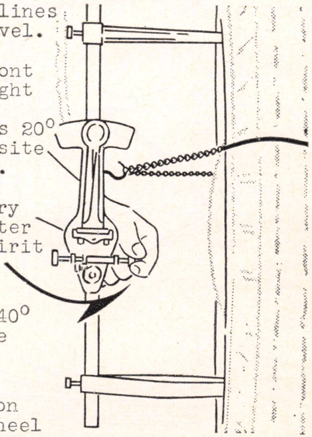
Be certain king pin inclination angle & camber angle are correct.



With front tires inflated to recommended pressure, centrally locate wheels in straight-ahead position on turntables.

Assemble gage to right wheel as instructed by tool manufacturer.Then remove turntable lock pins.

Turn wheels to left until right wheel turntable pointer just passes 20° mark,then back to exact 20° mark to relieve possible bind in steering mechanism.



Adjust secondary screw to center bubble between lines on spirit level.

Then turn front wheels to right until right wheel reaches 20° mark on opposite end of scale.

Adjust primary screw to center bubble in spirit level.

Readings on 40° scale will be caster.

Repeat test on left front wheel to obtain left wheel caster effect.

RESULT OF TESTS

Caster angle & camber angle,adjustable within certain limits on many types of front end suspension. When test readings are beyond these limits, or when no adjustment is provided, parts replacement is necessary to obtain the correct adjustment. Applying heat to straighten bent parts not recommended.

FRONT END ALINEMENT

TOE-IN

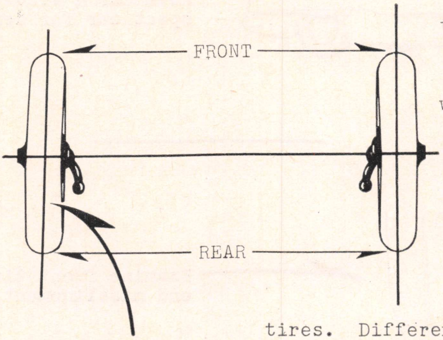
Toe-in is the setting, or adjusting, of front wheels so the distance between wheels is less at the front than at the rear. Toe-in is necessary to compensate tendency for front wheels to "RUN-OUT" caused by the camber angle.

TOE-IN - TESTS

Several gages are available to accurately check front wheel toe-in. Follow instructions furnished by gage manufacturer for best results.

When toe-in gage is not available, measurements may be made in the following manner.

Raise the front wheels. Spin wheels & using a piece of chalk, scribe a line in center of each tire tread.



Place front wheels on turntables in straight-ahead position.

NOTE-Turntables allow wheels to float freely, eliminating bind in steering connections.

Using suitable gage, measure distances between chalk lines at front & at rear of tires.

Distance should be greatest at rear of tires. Difference in measurement is toe-in.

TOE-OUT ON TURNS

When making a turn the front wheels must actually "TOE-OUT" so each wheel can be at a right angle to the radius on which it is turning.

This condition is obtained automatically by the angle, or amount the steering arms are positioned inward at the tie rod end.

TOE-OUT - TESTS

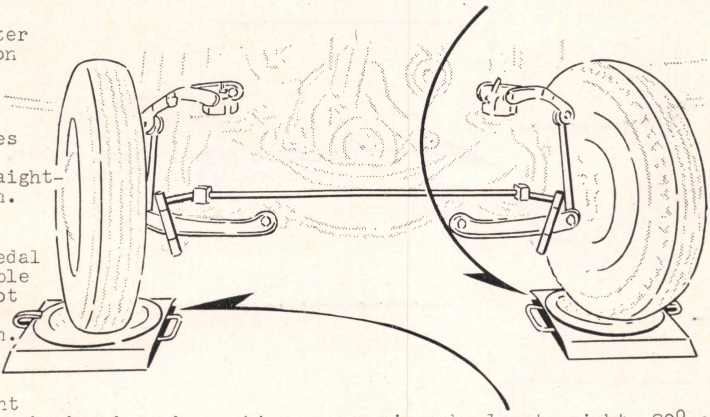
Prior to checking toe-out be certain all other factors of front end alinement are set to specifications.

Carefully center front wheels on turntables.

With turntables locked, turn wheels to straight-ahead position.

Using brake pedal jack or suitable tool, lock foot brakes in applied position.

Normalize front springs & shock absorbers by rocking car & allowing it to settle.



Remove lock pins from both turntables.

Turn wheels to left 20° as registered by indicator on turntable under left wheel.

Indicator on turntable under right wheel indicates amount of toe-out.

Check reading with specifications for car being checked.

Reverse procedure by turning wheels to right 20° on turntable under right wheel for left wheel test.

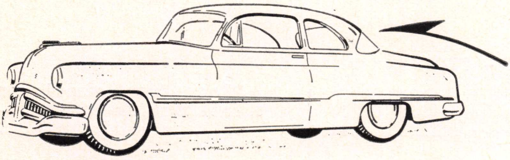
IMPORTANT

When toe-out is not within specified limits, it indicates one or both steering knuckle arms are bent.

Replace defective arm or arms. Heating or straightening arms to obtain toe-out is not recommended.

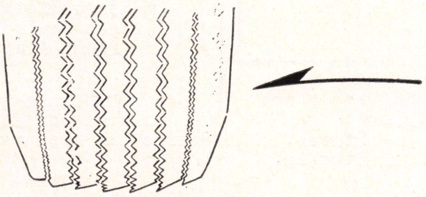
SUMMARY

GENERAL INSPECTION & FRONT END ALINEMENT TEST



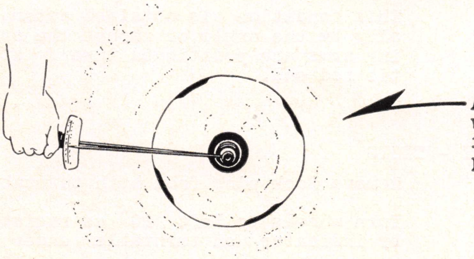
(1)

Inflate tires; Place car on level floor; Rock car & allow to settle; Visually inspect car for defective springs.



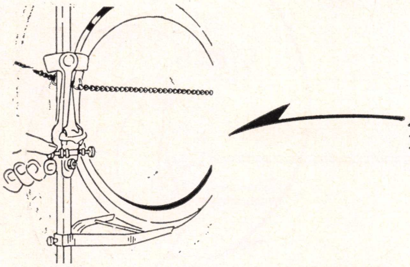
(2)

Examine front tires for evidence of front end misalinement.



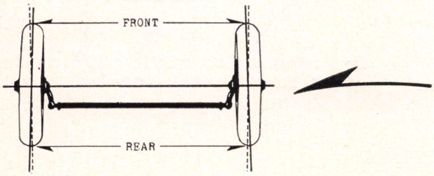
(3)

Adjust front wheel bearings; Check for wheel run-out; Check wheel balance; Check for wear in control arm bushings, knuckle pins & bushings, tie rod ends.



(4)

Attach gages. Make camber, caster & king pin inclination tests.



(5)

Mark tires. Make toe-in & toe-out tests.

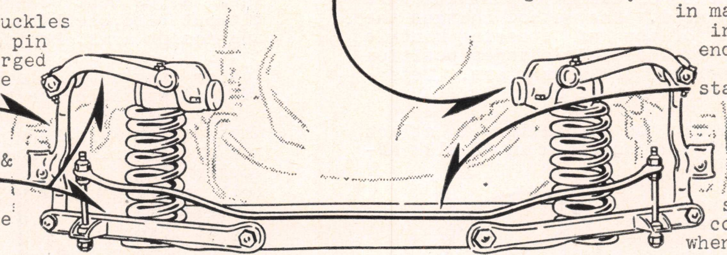
PARALLEL ARM FRONT SUSPENSION

Parallel arm type front suspension is constructed so car weight is suspended on independent coil springs at each front wheel.

Road shocks affecting one wheel do not affect the opposite wheel.

The steering knuckles pivot on a king pin mounted in a forged steering knuckle support.

Parallel upper & lower control arms attach the steering knuckle support arm to front frame cross member.Both ends of control arms are pivot points.



On some installations the upper control arm is incorporated in mechanism of the shock absorber. Others employ a forked upper control arm with shock absorber mounted inside coil spring, attached to upper & lower arms.

Since limiting car sway is important in maintaining front end alinement, a stabilizer bar is used to control body & frame sway encountered when rounding curves at high speeds. The bar is mounted in rubber bushed brackets of front frame.

KING PIN INCLINATION ADJUSTMENT

King pin inclination is predetermined by the manufacturer & is built into the vehicle.No adjustment is provided.

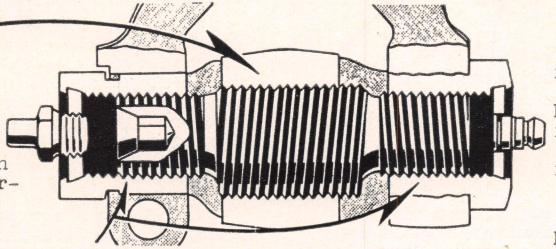
Unless related parts are damaged, king pin inclination will be correct when camber angle is correct.

CAMBER ANGLE ADJUSTMENT

Camber angle, in most installations,is controlled by means of a threaded eccentric bushing, located at outer end of the upper suspension arm.

Eccentric bushing is locked in adjustment by means of a clamp bolt in upper end of steering knuckle support arm.

Two threaded bushings attach the eccentric bushing to the outer end of the upper suspension arm.



Two rubber seals prevent dirt entering bushing threads.

Desired camber angle is obtained by turning eccentric bushing in upper suspension arm.

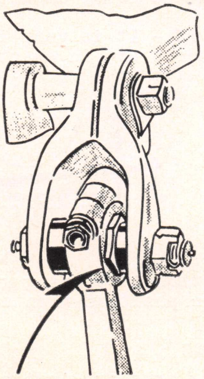
NOTE-Maximum adjustment for camber is 1/2 turn of bushing.

ADJUST CAMBER ANGLE

With camber gage in place, as outlined in "CAMBER ANGLE-TESTS", loosen eccentric bushing clamp bolt.

NOTE-Two types of eccentric bushings are used. One requires a special open end wrench for adjustment. The other requires an Allen wrench.

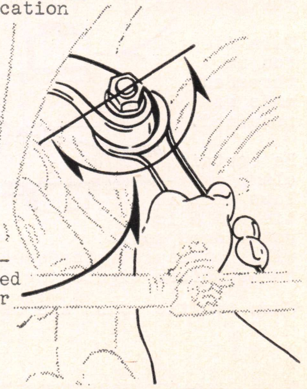
Determine which type wrench is necessary.



Use open end wrench on hexagon portion of eccentric bushing, or Allen wrench through lubrication fitting hole.

Move eccentric as necessary to obtain specified camber angle.

NOTE-When correct camber angle cannot be obtained in 1/2 turn or less, bent frame, bent steering knuckle arm or bent suspension arm is indicated.



PARALLEL ARM FRONT SUSPENSION

CASTER ANGLE ADJUSTMENT

The caster angle adjustment is accomplished by changing position of steering knuckle support arm. By moving top of support arm back, or moving bottom of support arm forward on some installations, caster angle is increased. Moving support arm ends in opposite direction decreases caster angle.

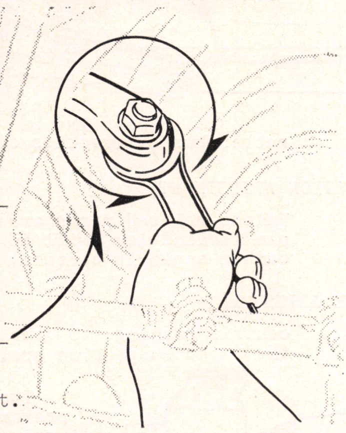
ADJUSTING CASTER ANGLE

Two methods of caster adjustment are commonly used. One method changes the position of top of steering knuckle support arm. The other changes position of the bottom of support arm. Determine which method is used.

Position car on turntables & attach caster gage as outlined in "CASTER ANGLE-TESTS".

When adjustment is made at top of support arm, the same threaded bushing is used as when camber adjustment is made.

It is obvious then that the bushing must be rotated in complete revolutions to hold camber angle constant.



NOTE - After caster adjustment is made be certain sufficient clearance exists between both sides of support arm & suspension arm.

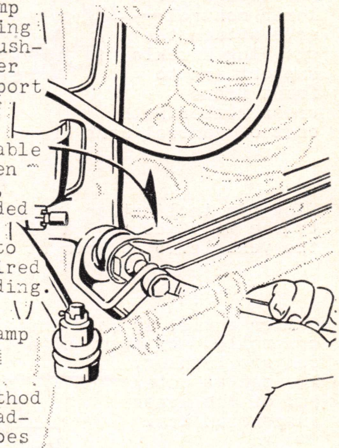
When adjustment cannot be obtained without bind, check for bent or damaged suspension arms. Replace if necessary.

Caster angle should be as near the same as possible for both front wheels.

When caster adjustment is made at bottom of steering knuckle support arm, loosen clamp bolt securing threaded bushing at lower end of support arm.

Using suitable off-set open end wrench, turn threaded bushing as necessary to obtain desired caster reading.

Tighten clamp bolt.



As this method of caster adjustment does not effect camber, it is not necessary to rotate threaded bushing in complete turns.

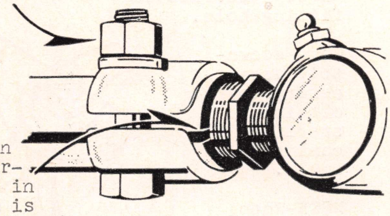
TOE-IN ADJUSTMENT

Front wheel toe-in adjustment is accomplished by lengthening or shortening the tie rod, or tie rods. Several types of gages are available to accurately measure toe-in. Follow instructions furnished by gage manufacturer.

ADJUSTING TOE-IN

To adjust toe-in loosen clamp bolts on tie rod ends.

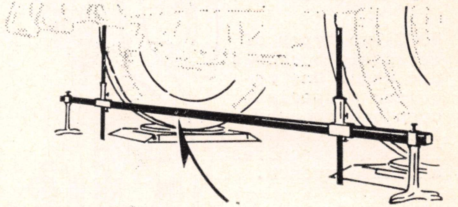
Turn tie rod in threaded ends as required.



Be certain clamp overlaps slot in tie rod & is positioned so it will not cause interference on extreme turns before tightening clamp bolt.

When two tie rods are used with central steering arm, both rods must be turned equal amounts.

NOTE - It is very important that front wheels are in exact straight-ahead position & steering gear is in exact center position when adjusting toe-in.



TOE-OUT ON TURNS

When toe-out measurements are in excess of specified limits, bent steering arms are indicated. Both steering arms should be replaced with new ones.

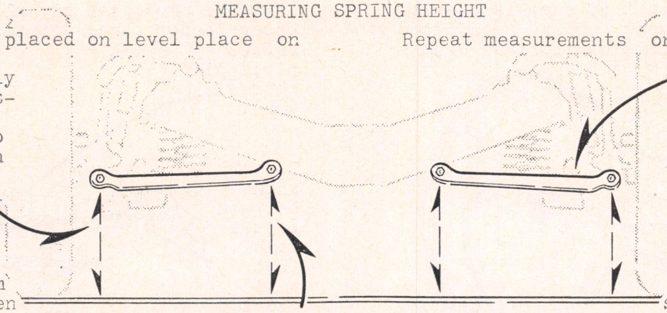
PARALLEL ARM FRONT SUSPENSION

FRONT & REAR SPRINGS

Front & rear springs that vary in height from one side of car to the other side will seriously affect all alinement angles.

It is important that there be not more than 1/4" difference in front spring height or 3/4" difference in the rear spring height.

MEASURING SPRING HEIGHT



With the car placed on level place on floor & all tires properly inflated, measure distance from floor to given spot on outer end of lower control arm.

Then measure distance from floor to given spot on inner end of lower control arm.

NOTE - Center of lubrication fitting makes suitable spot for the measuring point.

Repeat measurements on opposite side of car.

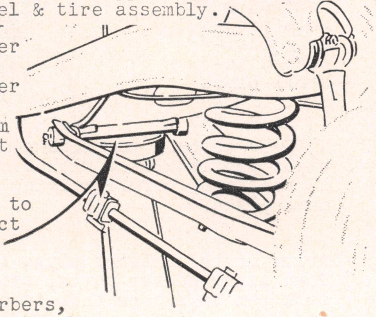
There should be not over 1/4" difference in these measurements.

When difference in front spring height is too great, check height of rear springs by measuring distance from spring plates to frame on each side of car.

A difference of 3/4" in rear spring height will affect front spring height.

FRONT COIL SPRING-REPLACE

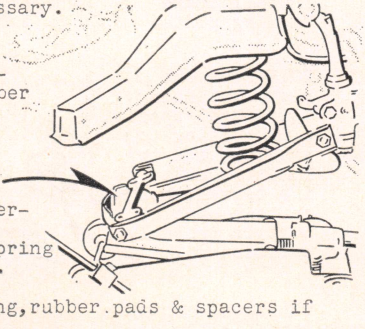
REMOVE: Raise car so front wheels are off of floor. Place suitable support stands under each frame side member near rear engine support crossmember. Remove wheel & tire assembly.



Place roller type jack under center of lower control arm inner pivot bar.

Raise jack to just contact pivot bar.

Disconnect shock absorbers, sway eliminator bar & other accessories as necessary.



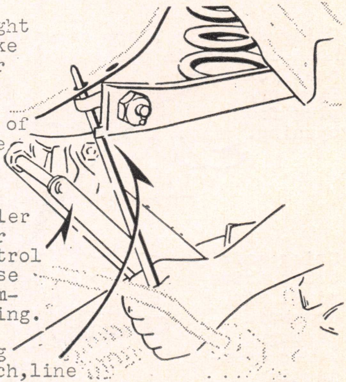
Remove the inner shaft-to crossmember attaching bolts.

Release roller jack slowly, lowering control arm until spring is unloaded.

Remove spring, rubber pads & spacers if used.

INSTALL: Stand spring on end, flat end up. Place rubber silencer pad & spacer if used, on flat end of spring. Place rubber silencer pad in lower control arm seat.

Position spring & silencer in recess in frame crossmember. Turn spring so lower end will index recess in lower control arm. Then move lower control arm up to hold spring in position.



Using bright light, make sure upper end of spring & lower end of spring are properly located.

Place roller jack under lower control arm & raise arm to compress spring.

Using long drift punch, line up control arm attaching bolt holes. Install & tighten attaching bolts.

NOTE- When installing spacer washer to make spring height correction, it is not advisable to use more than two 1/8" spacers on one spring. When more spacers are required, use new spring.

PARALLEL ARM FRONT SUSPENSION

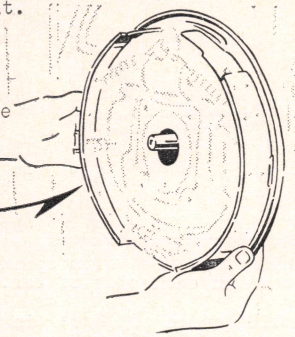
STEERING KNUCKLE ASSEMBLY

The steering knuckle is supported in various ways. For example some designs incorporate the supporting yoke integral with the knuckle, while on others the supporting yoke is integral with the support arm.

Replacement procedures are similar on both types.

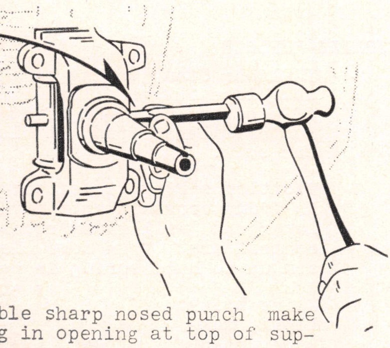
STEERING KNUCKLE-REMOVE-INSTALL

REMOVE: Raise front of car. Place suitable support stands under each frame side member. Remove wheel, brake drum & hub as a unit.



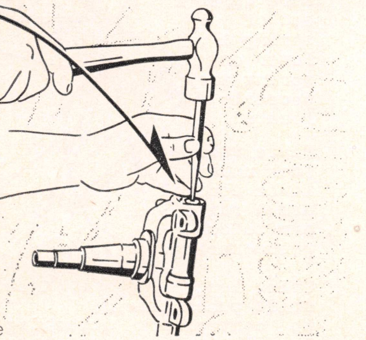
Remove brake backing plate attaching bolts & remove backing plate.

NOTE-Do not disconnect brake hose when not necessary. Wire plate to frame to protect brake hose.



Drive out pivot pin tapered lock pin.

NOTE-On some installations steering arm acts as pivot pin lock.

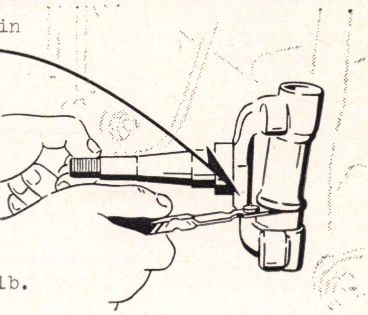


Using suitable sharp nosed punch make hole in plug in opening at top of support yoke. Then pry plug from opening.

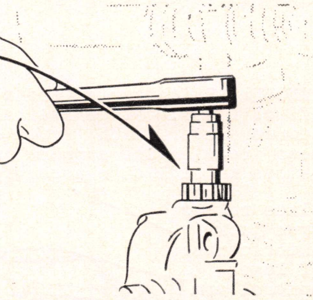
Using soft drift, drive pivot pin downward through lower opening in yoke, at same time forcing out lower opening plug.

NOTE-When steering knuckle is equipped with needle or ball type bearings, use care to prevent damage to the bearings while driving out pivot pin.

INSTALL: Position knuckle on support. Using feeler gage, determine clearance between pivot pin boss & yoke.



Install shim between boss & yoke that will provide 1 to 3 lb. pull to rotate steering knuckle on pivot pin.



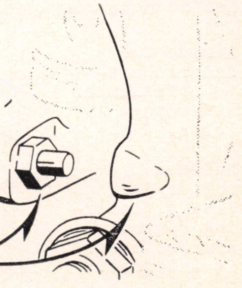
Using suitable reamer, clean plug openings at both ends of yoke.

With knuckle thrust bearing & shim properly positioned install pivot pin.

NOTE-Be certain the lock pin recess in pivot pin is alined with lock pin hole in pin boss before driving pivot pin into place.

Drive upper & lower plugs into place. Then using center punch, stake plugs & lock pin to secure them in position.

Install brake backing plate.



NOTE-When one plate attaching bolt is of special construction to provide stop to limit wheel turning travel, be certain special bolt is properly positioned.

Lubricate knuckle bearings. Install wheel, brake drum & hub assembly.

PARALLEL ARM FRONT SUSPENSION

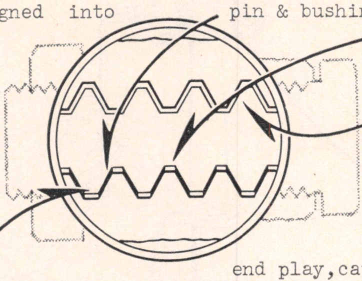
THREADED STEEL BUSHING CLEARANCE

Hardened threaded steel bushings are used at many points of front suspension linkage.

Built-in clearance is designed into these bushings to prevent binding under deflection.

Threaded bushings of the front suspension system require more clearance than smooth pin & bushing type.

The threaded pin floats in the "V" shaped thread-cut in bushing.



Under normal load, edge of pin bears against the "V".

Illustration shows contact points at pin & bushing; Clearance at points of "V"; All around clearance at opposite side of pin when under load.

These clearances must exist to assure freedom of movement.

Threaded pins & bushings should not be replaced unless they have excessive end play, cause noise or cause unstable steering.

IMPORTANT

Always apply coat of light engine oil to inside & outside threads of hardened threaded steel bushings before installation.

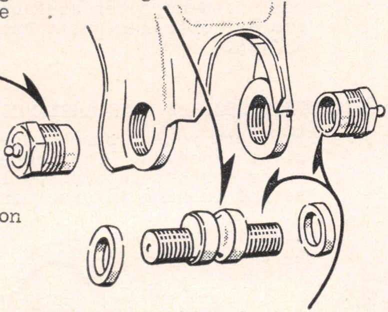
Be certain the hardened threaded steel bushings are properly lubricated with good grade chassis lubricant after installation.

UPPER CONTROL ARM OUTER PIVOT

The upper control arm outer pivot provides a bearing for the top end of the steering knuckle support arm. Free up & down movement must be maintained with no forward or backward movement. Methods of installing pivot to obtain free vertical movement are slightly different with the various types.

UPPER CONTROL ARM OUTER PIVOT-TYPES

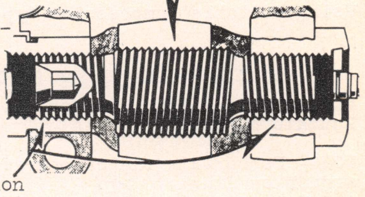
Figure 1 shows a pivot that is threaded on both ends. The center eccentric portion being smooth & grooved to accommodate the clamp bolt.



Two hardened threaded steel bushings secure pivot in upper suspension control arm.

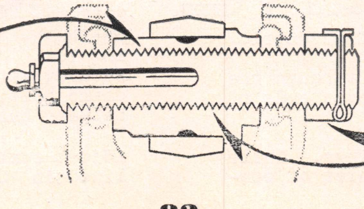
Bearing is on threaded portion of pivot & bushings. "V" thread design prevents end play under normal load.

Figure 2 shows a pivot that is threaded on the eccentric portion as well as on both ends.



Two hardened threaded steel bushings attach pivot to upper suspension arm. Bearing is on threaded ends of pivot & threaded bushings. "V" thread design prevents end play under normal load.

Figure 3 shows an eccentric that is bored & threaded to accommodate the attaching bolt. Outer surface of the eccentric is smooth. A groove cut around the eccentric indexes the clamp bolt.



The attaching bolt threads into threaded bore of eccentric & into one leg of upper suspension control arm & is secured with a lock nut.

Bearing is on threaded attaching bolt & threaded inner bore of pivot.

PARALLEL ARM FRONT SUSPENSION

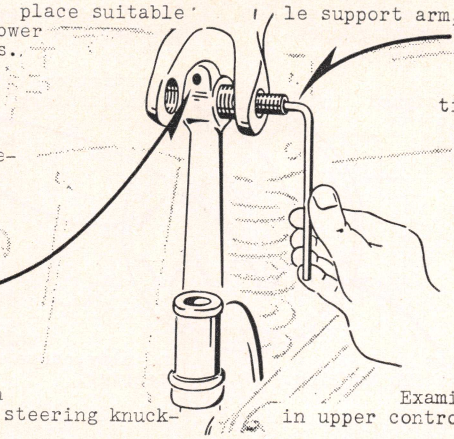
UPPER CONTROL ARM OUTER PIVOT-REMOVE

Raise front of car & place suitable support stands under lower control arm spring pads. Remove wheel assembly.

Place suitable support under spindle or wire spindle to frame to prevent brake hose damage when pivot is removed.

Remove clamp bolt from upper end of steering knuckle support arm.

Remove front & rear pivot bushings, or threaded attaching bolt. Remove pivot. When pivot is threaded into steering knuckle support arm, use camber adjusting wrench to remove pivot.



NOTE-Make note of position of camber adjustment opening, to front or rear, so it will be re-installed in same position.

Inspect parts for wear or other damage.

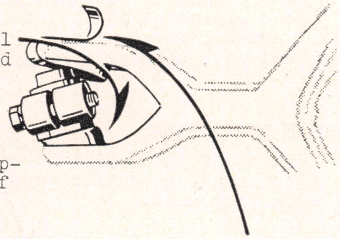
Be certain threads in bushings do not bottom in threads on pivot.

Examine condition of threads in upper control arm bushing openings.

UPPER CONTROL ARM OUTER PIVOT-INSTALL (ECCENTRIC SECURED WITH THREADED BOLT)

Position eccentric bushing in steering knuckle support arm.

NOTE-Be certain camber adjustment hexagon end is positioned as on original installation. Lock bushing with clamp bolt.

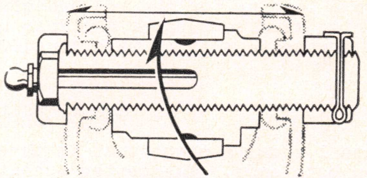


Place new seal on hexagon end of bushing.

Place second new seal in opposite boss of control arm.

Using suitable compression type clamp, compress seal in control arm & position steering knuckle support in control arm.

While holding knuckle support arm centered in control arm, thread attaching bolt through eccentric & into boss of control arm.

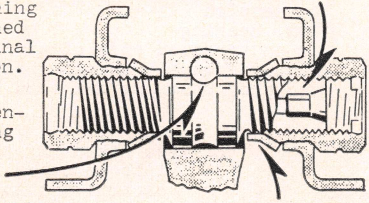


Tighten bolt until specified measurement between outer surfaces of control arm are obtained. Reset camber & caster angles.

UPPER CONTROL ARM OUTER PIVOT-INSTALL (ECCENTRIC SECURED WITH THREADED BUSHINGS)

Position eccentric bushing in steering knuckle support.

NOTE- Be certain the camber adjustment wrench opening is positioned as on original installation.



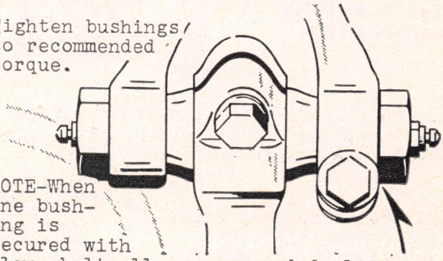
Center eccentric bushing & install clamp bolt.

Place new seals on ends of eccentric.

NOTE-Seals can be inserted through the openings in control arm & over ends of eccentric.

Lubricate threads of bushings. While holding support arm in center of control arm yoke, start one bushing on pivot threads. Then carefully index outer threads into control arm. Start second bushing in same manner.

Tighten bushings to recommended torque.



NOTE-When one bushing is secured with clamp bolt, allow recommended clearance between bushing head & control arm.

Adjust camber & caster as outlined in "CAMBER & CASTER ADJUSTMENT".

PARALLEL ARM FRONT SUSPENSION

UPPER CONTROL ARM ASSEMBLY-REPLACE

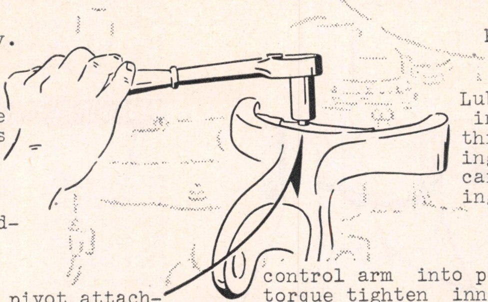
REMOVE: Raise front of car.Place suitable support stand under lower control arm spring pad.Remove wheel assembly.

Wire spindle to frame to prevent brake hose damage when upper control arm is removed.

Remove upper pivot threaded bushings or bolt.

Remove control arm inner pivot attaching bolts.

NOTE - Some installations employ shims between inner pivot bar & frame.Do not lose shims.



INSTALL: Place new seals on ends of outer pivot.

Position outer yoke over pivot.

Lubricate pivot bushing threads, or bolt threads. Thread bushings onto pivot, then carefully index bushing threads into control arm.

Swing inner end of control arm into position. Install & torque tighten inner pivot attaching bolts.

Torque tighten outer pivot bushings.

Reset camber & caster angles as outlined in "CAMBER & CASTER-ADJUSTMENT".

UPPER CONTROL ARM INNER PIVOT-REPLACE

REMOVE: Remove upper control arm as outlined in"UPPER CONTROL ARM-REPLACE"

Place upper control arm in vise or suitable holder.

Remove pivot bar end bushings, seals & pivot bar.

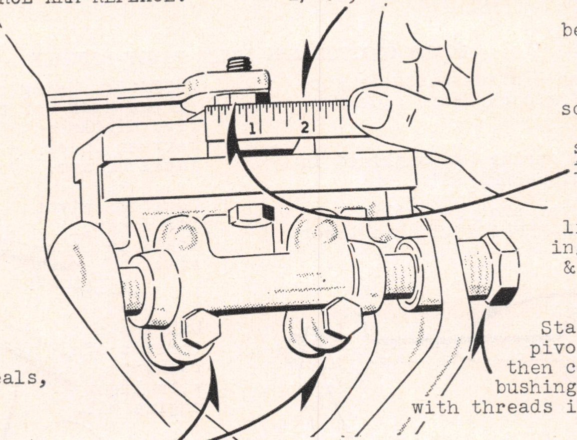
When old control arm is to be used, be certain threads in yoke arm bosses are in good condition.

INSTALL: Position new pivot bar, with new seals, in control arm.

Attach special spreader tool to the pivot bar attaching lugs with two bolts furnished with tool.

Tighten tool expander tool wedge screw by hand until jaws are just snug against inside webs of control arm yoke.

NOTE- When tool is properly installed, both jaws will contact webs of yoke at same time. When one jaw makes contact before the other, improper tool installation or bent control arm is indicated.



Position steel scale, graduated in 1/16", across base of expander tool. Note distance between the two lines.

Tighten wedge screw until arm yoke has been spread approximately 1/16".

Apply coat of light lubricating oil to inner & outer bushing threads.

Start bushings on pivot bar threads, then carefully index bushing outer threads with threads in control arm.

Thread bushings into control arm until shoulders of bushings contact surface of control arm. Tighten bushings to recommended torque.

Remove spreading tool & test operation of pivot bar for free movement. A moderate grip should be required to turn pivot.

CAUTION- Do not rotate pivot bar. This would move pivot off center.

Install the control arm as outlined in "UPPER CONTROL ARM ASSEMBLY-REPLACE".

IMPORTANT

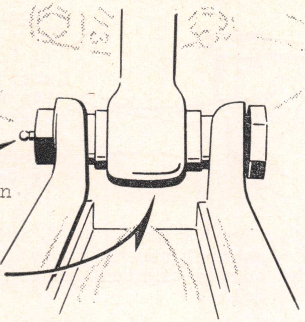
Upper & lower control arms, pivot bars & coil springs are heat treated parts. No attempt should be made to straighten bent parts either cold or hot.

PARALLEL ARM FRONT SUSPENSION

LOWER CONTROL ARM PIVOT PIN-REPLACE

REMOVE: Raise car off floor. Place suitable support stand under lower control arm spring pad.

Remove wheel & tire assembly.

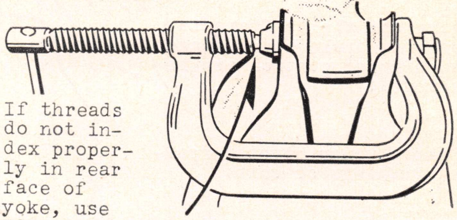


Remove lock nut, washer & lower pivot pin.

INSTALL: Position knuckle arm as nearly as possible in center of lower control arm yoke.

To facilitate installation of seals, slip new seals over ends of lower control arm yoke approximately 1".

While holding knuckle support arm in center of yoke, thread pivot bolt in yoke, through bushing & into opposite side of yoke.



If threads do not index properly in rear face of yoke, use "C" clamp to slightly compress yoke until threads do index.

Using wire hook, move seals into place. Tighten bolt to specified torque. Install & tighten lock nut.

LOWER CONTROL ARM INNER PIVOT BAR

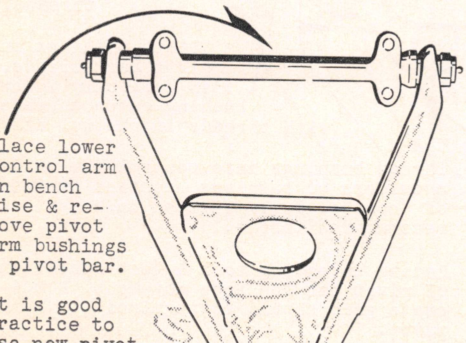
When replacing the lower control arm, inner pivot shaft or pivot shaft bushings, it is good practice to remove the control arm from car to insure proper spacing of arm yoke. These operations should be performed on the bench.

LOWER CONTROL ARM INNER PIVOT-REPLACE

REMOVE: Raise car & place suitable support stands under each frame side member.

Remove the coil spring as outlined in "FRONT COIL SPRING-REPLACE".

Remove lower pivot pin as outlined in "LOWER PIVOT PIN-REPLACE". Remove lower control arm.

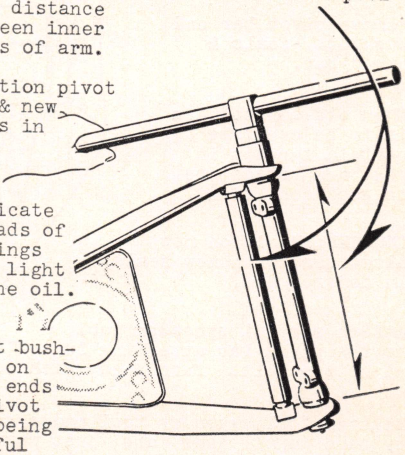


Place lower control arm in bench vise & remove pivot arm bushings & pivot bar.

It is good practice to use new pivot bar bushings when assembling lower control arm.

When assembling lower control arm, pivot bar & bushings, special spreader tool is necessary to spread control arm to relieve tension of threads after bushings have been installed.

INSTALL: Using suitable spreader tool spread ends of control arm to specified distance between inner faces of arm.



Position pivot bar & new seals in arm.

Lubricate threads of bushings with light engine oil.

Start bushings on both ends of pivot bar, being careful threads are indexed.

Thread bushings onto pivot bar until shoulders contact surfaces of control arm. Then torque tighten to recommended torque.

Remove spreader & test for free operation of pivot bar. Distance from pivot bar attaching bolt holes to inner face of control arm must be equal on both sides of control arm.

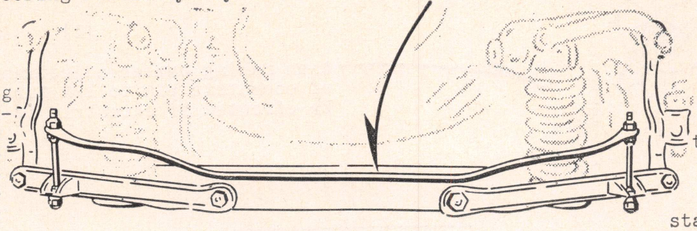
Install the control arm as outlined in "FRONT COIL SPRING-INSTALL".

PARALLEL ARM FRONT SUSPENSION

STABILIZER BAR (SWAY ELIMINATOR)

A front stabilizer bar (sway bar) is used on parallel arm front suspension to provide steering stability by limiting body & frame roll on curves.

Since limiting sway is important in maintaining front end alinement on curves, it is good practice to see that the stabilizer bar & connecting links are in proper working condition.



The stabilizer bar is a solid steel bar attached to the frame by means of rubber bushed brackets. Each end of the bar is attached to each lower suspension control arm by means of links or retainer brackets.

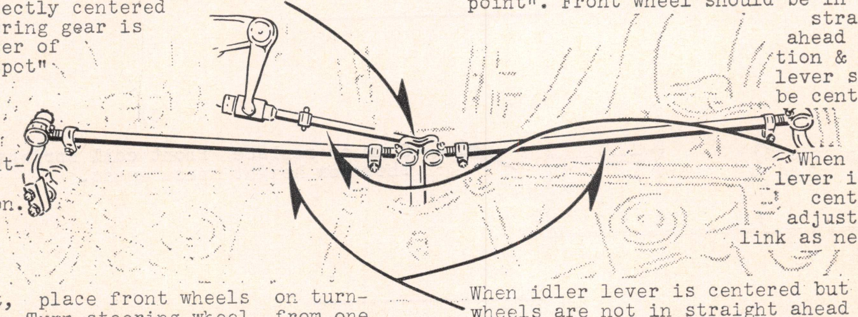
Be certain stabilizer bar, attaching bolts, brackets & links are properly attached & in good condition.

FRONT SHOCK ABSORBERS

Since limiting front end bounce is important to maintain front end alinement on rough roads, it is important to be certain front shock absorbers are in good working condition when checking front end alinement.

CENTERING OF STEERING IDLER LEVER

The steering linkage idler shaft must be correctly centered so steering gear is on center of "high spot" when front wheels are in straight-ahead position.



To test, place front wheels on turntables. Turn steering wheel from one extreme position to the other, counting number of turns. Then turn wheel back 1/2 the total number of turns.

This places the steering gear on "high point". Front wheel should be in exact straight-ahead position & idler lever should be centered.

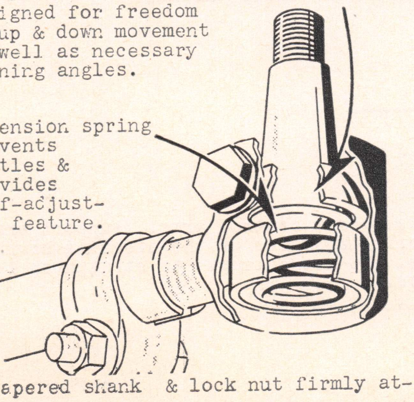
When idler lever is not centered, adjust drag link as needed.

When idler lever is centered but front wheels are not in straight ahead position, adjust both tie rods an equal amount as needed. Recheck toe-in & toe-out adjustments.

TIE ROD ENDS-REPLACE

Tie rod ends are a "dual-bearing" type designed for freedom of up & down movement as well as necessary turning angles.

A tension spring prevents rattles & provides self-adjusting feature.

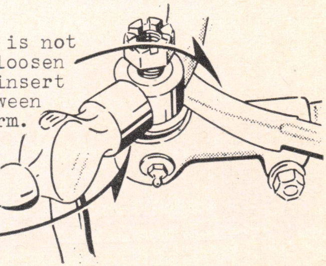


A tapered shank & lock nut firmly attaches tie rod ends to the steering arms & idler lever.

Use suitable puller to remove tie rod ends.

When puller is not available, loosen lock nut & insert pry bar between tie rod & arm.

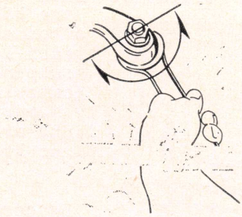
A few light taps on end of arm will jar taper loose.



When assembling tighten the lock nut & clamp bolt to specified torque. Recheck toe-in adjustment.

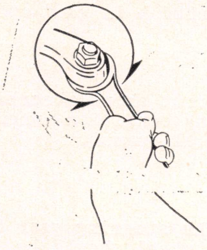
SUMMARY

PARALLELL ARM FRONT SUSPENSION ADJUSTMENT



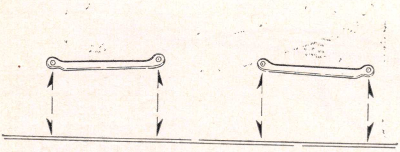
(1)

When making camber adjustment limit turns of eccentric pin to 1/2 turn. Caster will be effected if eccentric is turned more.



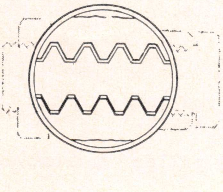
(2)

When making caster adjustment turn eccentric pin in complete turns. Camber is effected when pin is turned less.



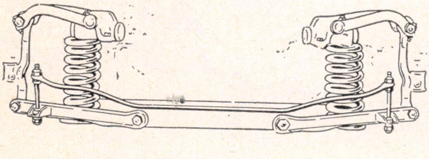
(3)

Shim or replace front coil springs that show low height measurement.



(4)

Be certain threaded hardened steel bushings,used for replacement, have necessary clearance on inner threads.

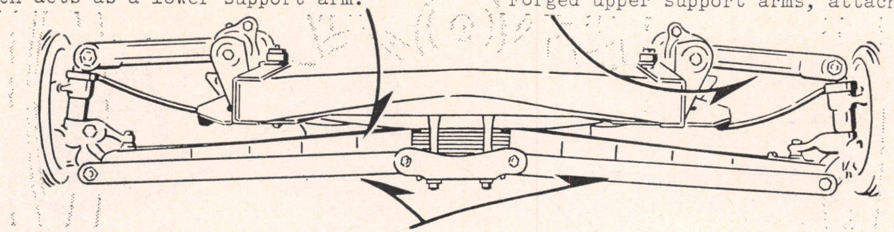


(5)

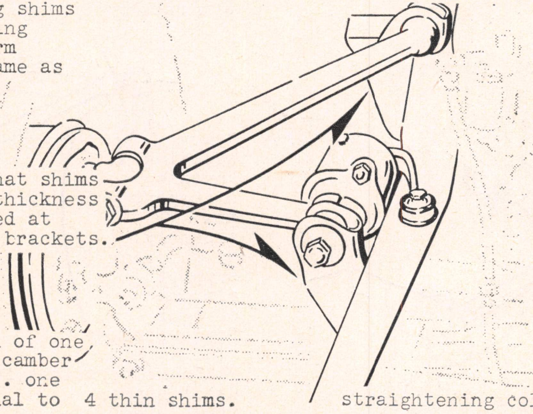
Replace bent control arms, support arms, steering knuckles or the steering knuckle arms. Do not attempt to straighten bent parts.

PLANAR SUSPENSION

Planar type suspension employs a conventional leaf type transverse spring which acts as a lower support arm. The transverse spring is supplemented by two stamped steel control links attached to steering knuckles & spring center support plate. Forged upper support arms, attached to frame by widely spaced mountings maintain alinement & resist braking torque.



CAMBER & CASTER ANGLES-ADJUST



Camber angle adjustment is obtained by removing or adding shims between the steering knuckle support arm brackets & the frame as required.

It is important that shims of same number & thickness be removed or added at both front & rear brackets.

Removal & addition of one thin shim changes camber approximately 1/4°. one thick shim is equal to 4 thin shims.

Caster angle is maintained by relation of the front spring to the frame & is not adjustable.

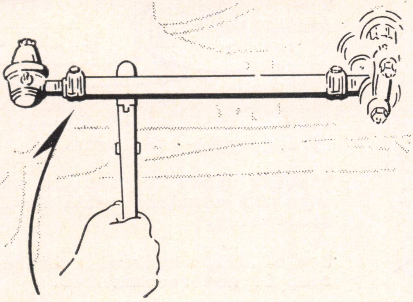
When caster tests indicate + or - caster beyond specified limits, bent or worn parts are indicated.

Bent or worn parts should be replaced.

Heating parts for straightening or straightening cold is not recommended.

TOE-IN --- TOE-OUT

TOE-IN: Adjust-Position steering wheel in exact center position, 1/2 total number of turns required to rotate the wheel from one extreme to the other, & left front wheel in exact straight-ahead position.

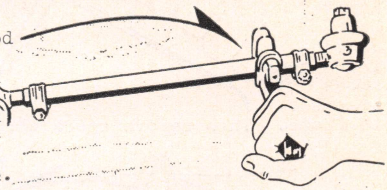


NOTE-
If left wheel is not in exact straight-ahead position, loosen the clamp bolts on left tie rod ends.

Adjust left tie rod as needed to position the left front wheel as desired. Tighten clamp bolts & do not disturb during remainder of adjustment.

Loosen clamp bolts on right tie rod ends.

Using pipe wrench or suitable tool, turn right tie rod as needed to obtain specified toe-in.



NOTE-
Be certain steering wheel & left front wheel have not moved from center position.

TOE-OUT: When toe-out is not within specified limits, bent steering arms or worn parts are indicated. Replace defective parts.

CAUTION-Straightening of parts, hot or cold, is not recommended.

PLANAR SUSPENSION

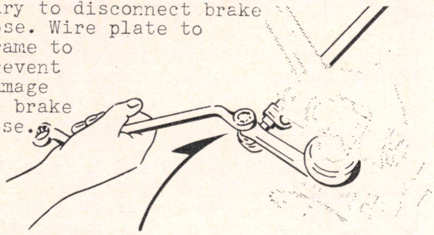
UPPER SUPPORT ARM & STEERING KNUCKLE ASSEMBLY

REMOVE: Raise front of car. Place suitable support stand under transverse spring near outer end.

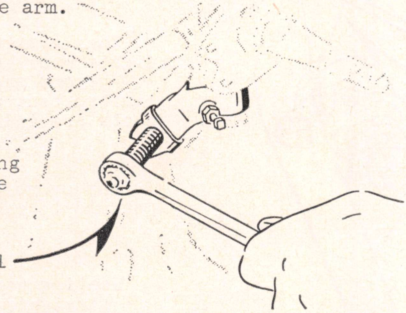
CAUTION- Do not use stamped steel control arm as support when lifting or supporting car.

Remove wheel & hub assembly from spindle.

Remove brake backing plate. Not necessary to disconnect brake hose. Wire plate to frame to prevent damage to brake hose.

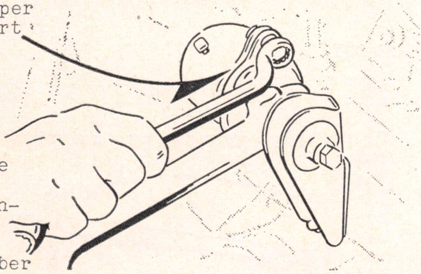


Disconnect the tie rod from steering knuckle arm.

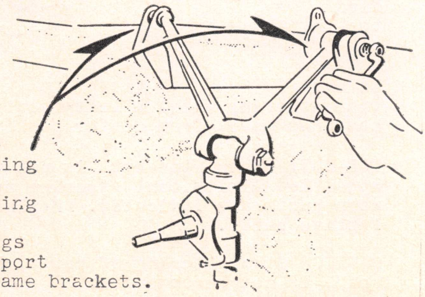


Remove spring bolt from spring eye, steering knuckle yoke & outer end of control arm.

Remove bolts attaching shock absorber to upper support arm.

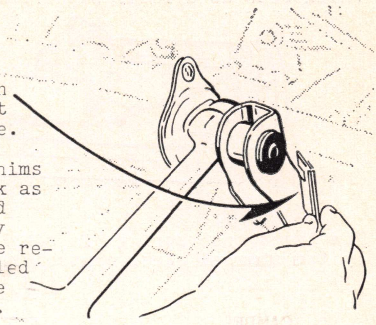


Remove bolt attaching shock absorber to frame. Then remove shock absorber.



Remove attaching screws retaining rubber bushings of support arm frame brackets.

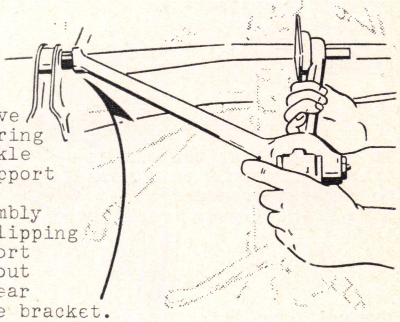
Remove support arm front frame bracket attaching bolts.



Remove shims between bracket & frame.

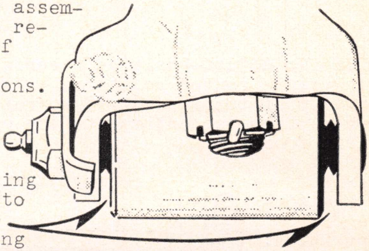
Keep shims in pack as removed so they will be reinstalled in same amount.

Slide front frame bracket off support arm rubber bushing.



Remove steering knuckle & support arm assembly by slipping support arm out of rear frame bracket.

INSTALL: Operations for installation of upper support arm & steering knuckle assembly are reverse of removal operations.



When installing spring to knuckle attaching bolt it is important that equal clearance be maintained between sides of spring eye & yoke arms.

Dipping upper support arm rubber bushings in gasoline will facilitate installation.

Use of oil, hydraulic brake fluid or soap is not recommended.

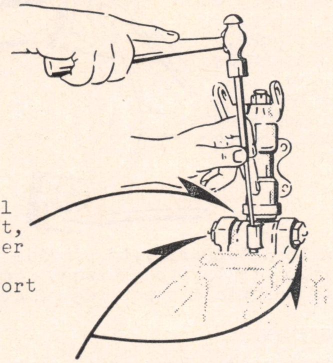
Be certain shims are correctly placed between support arm front frame bracket & frame.

Recheck camber, caster, king pin inclination, toe-in & toe-out.

PLANAR SUSPENSION

STEERING KNUCKLE

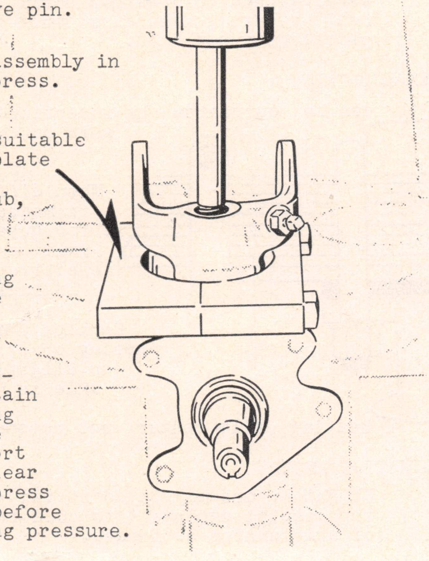
REMOVE: Remove the upper support arm & steering knuckle assembly as outlined in "UPPER SUPPORT ARM & STEERING KNUCKLE".



Place assembly in vise equipped with soft jaws.

Using small shank drift, remove taper pin which locks support arm pin in knuckle.

Remove support arm pin outer bushings & remove pin.



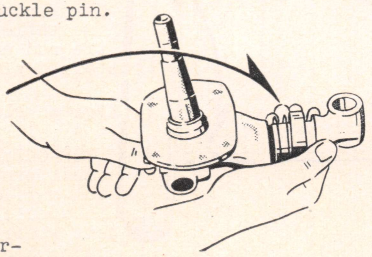
Place assembly in arbor press.

Using suitable split plate around yoke hub, press yoke from steering knuckle pin.

CAUTION-
Be certain steering knuckle & support arms clear arbor press plate before applying pressure.

Remove steering knuckle pin, bearing & shim from knuckle.

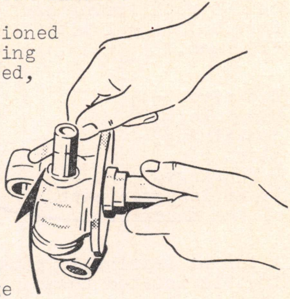
INSTALL: Position the thrust bearing & shims on knuckle pin.



Place pin in steering knuckle.

NOTE-Handle shims carefully to prevent burring, bending or other damage that may give false pin end play measurements.

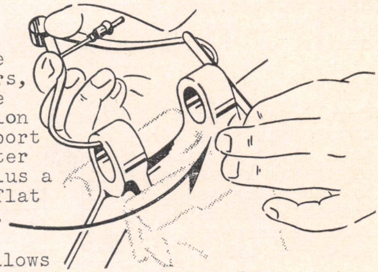
Steering knuckle pin end play must be held to specified limits.



With pin positioned so thrust bearing is firmly seated, place feeler gage of specified end play thickness on shoulder of steering knuckle.

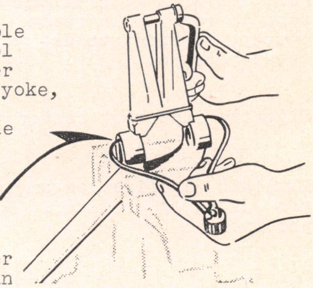
Upper edge of gage should be flush with edge of shoulder on steering knuckle pin.

Add or remove shims as needed to obtain measurement. Install lower yoke on end of pin. Torque tighten attaching nut.



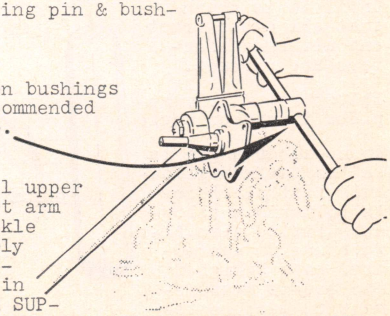
Using outside calipers, measure dimention of support arm outer yoke plus a .010" flat feeler.

This allows caliper measurement of .010" greater than actual outside dimention.



Using suitable spreader tool between inner surfaces of yoke, spread yoke until outside measurement corresponds to caliper measurement.

With spreader tool still in position so yoke is spread .010", install steering knuckle, attaching pin & bushings.



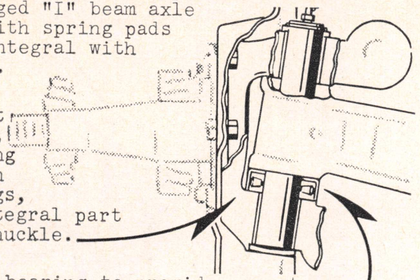
Tighten bushings to recommended torque.

Install upper support arm & knuckle assembly as outlined in "UPPER SUPPORT ARM & KNUCKLE ASSEMBLY-INSTALL".

SOLID AXLE SUSPENSION

REVERSE ELLIOTT TYPE

The reverse Elliott Type is a steel drop-forged "I" beam axle center with spring pads forged integral with "I" beam.

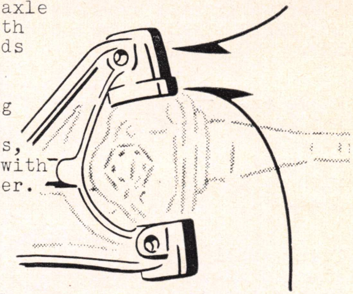


The pivot pin yoke, containing pivot pin & bearings, is an integral part of the knuckle.

A thrust bearing, to provide easy turning, is located between bottom surface of the axle end & lower leg of knuckle yoke.

ELLIOTT TYPE

Elliott Type is a steel drop-forged "I" beam axle center with spring pads & knuckle pin yoke, containing pivot pin & bearings, integral with axle center.

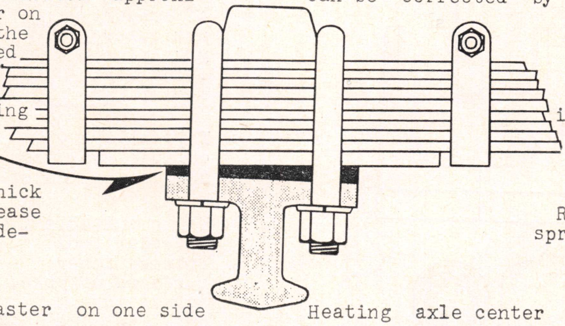


A thrust bearing, to provide easy turning, is located between upper surface of knuckle & upper leg of axle yoke.

CAMBER ANGLE ADJUSTMENT

No adjustment is provided for camber angle correction. When camber angle is not within specified limits, bent axle center or bent steering knuckle are indicated. Bent axle centers may be straightened cold within small limits. Bent steering knuckles must be replaced with new ones.

CASTER ANGLE ADJUSTMENT



When caster test indicates approximately the same error on both sides of axle, the error can be corrected by inserting wedge shaped shims between springs proper & spring seats (on axle).

Position shim with thick part to rear to increase caster, to front to decrease caster.

Slightly incorrect caster on one side can be corrected by inserting wedge shim on one side only.

When difference in measurement is too great, bent axle center or defective spring is indicated.

Replace defective spring or straighten slightly bent axle as needed.

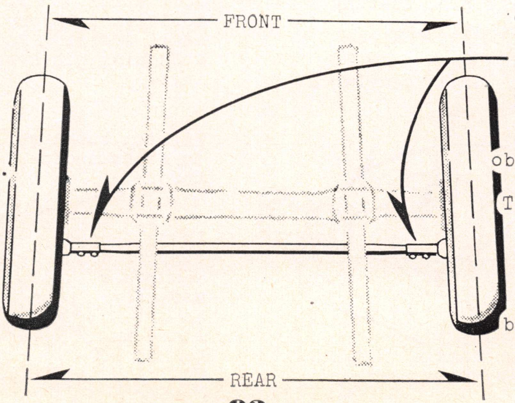
Heating axle center not recommended.

KING PIN INCLINATION ANGLE

King pin inclination angle & camber are directly related. No adjustment provided.

Slight errors may be corrected by using special equipment to cold bend end of axle center as needed.

TOE-IN -- TOE-OUT



Toe-in correction should not be made until it is known that all other front end alinement factors are correct.

This particularly applies to camber angle.

When camber angle is set to maximum allowable limits, set toe-in to maximum allowable limits also. Always use an accredited gage designed for toe-in measurement to measure toe-in.

To adjust, loosen tie rod end clamp screws at both ends of rod.

Using pipe wrench or suitable tool, turn tie rod as needed to obtain desired toe-in.

Tighten clamp screws.

TOE-OUT: No adjustment provided. When toe-out is not within specified limits, bent steering knuckle arms are indicated. Replace defective parts.

STEERING KNUCKLE BEARINGS

Steering knuckle bearings may consist of two bushing type bearings or it may employ a combination bushing & needle type bearing. A thrust bearing is employed to support car weight & provide easy turning.

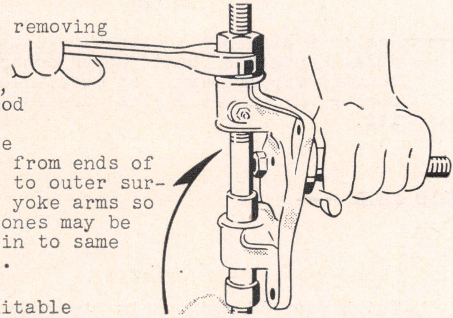
STEERING KNUCKLE BEARINGS-REPLACE

REVERSE ELLIOTT TYPE KNUCKLE

On reverse Elliott Type knuckle, pivot bearings are contained in a yoke which is an integral part of the knuckle.

REMOVE: Remove steering knuckle as outlined in "STEERING KNUCKLE-REMOVE".

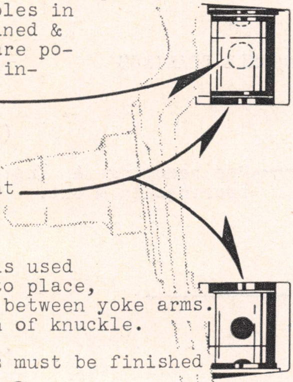
Prior to removing steering knuckle bearings, it is good practice to notice distance from ends of bearings to outer surfaces of yoke arms so the new ones may be pressed in to same position.



Using suitable removing tool, press out old bearings.

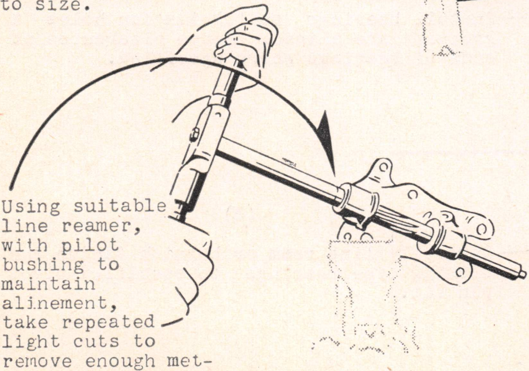
INSTALL: Position new bearing in yoke arm so lubrication holes in bearing & arm are alined & lubrication grooves are positioned as original installation.

Using suitable installing tool, press bearing into place allowing clearances at ends as noted before removal.



NOTE-If arbor press is used to press bearings into place, use suitable spacer between yoke arms to prevent distortion of knuckle.

Bushing type bearings must be finished to size.

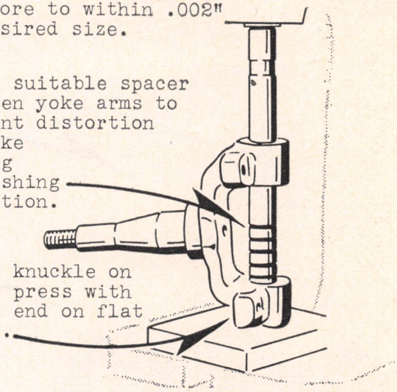


Using suitable line reamer, with pilot bushing to maintain alinement, take repeated light cuts to remove enough metal to obtain specified pivot pin fit.

When burnishing method is used to finish size the bushing bore, use line reamer to rough cut bore to within .002" of desired size.

Place suitable spacer between yoke arms to prevent distortion of yoke during burnishing operation.

Place knuckle on arbor press with lower end on flat plate.



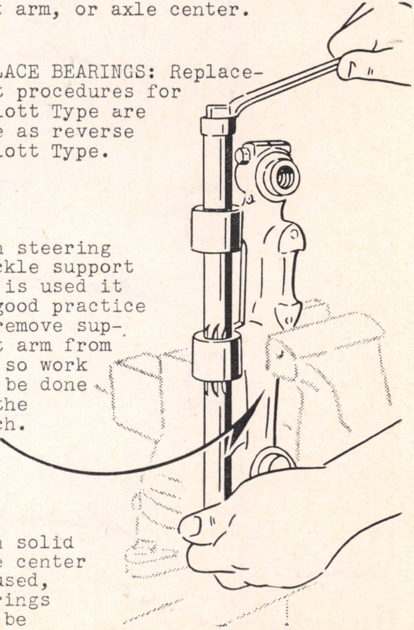
Press burnishing tool through bushing, removing only enough metal to obtain specified pivot pin clearance.

ELLIOTT TYPE KNUCKLE

On Elliott Type knuckle, pivot bearings are contained in a yoke which is an integral part of the knuckle support arm, or axle center.

REPLACE BEARINGS: Replacement procedures for Elliott Type are same as reverse Elliott Type.

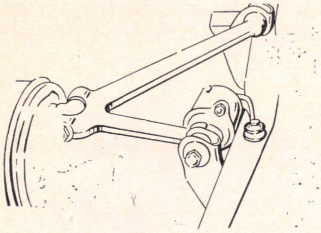
When steering knuckle support arm is used it is good practice to remove support arm from car so work may be done on the bench.



When solid axle center is used, bearings may be replaced without removing axle center.

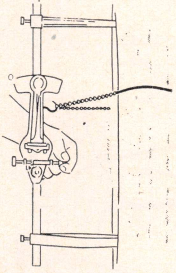
SUMMARY

PLANAR SUSPENSION



(1)

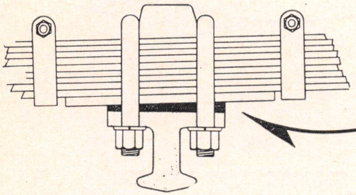
Remove or add equal thickness of shims at both front & rear brackets when adjusting camber.



(2)

Caster & king pin inclination not adjustable. Look for bent upper control arm, knuckle support arm, or defective front spring when these angles are out of limits.

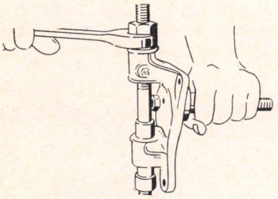
SOLID AXLE



(1)

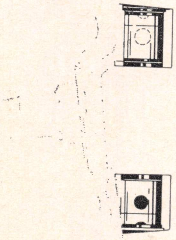
Thick part of wedge shim to rear to increase caster, to front to decrease caster.

STEERING KNUCKLE BEARINGS



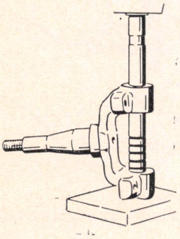
(1)

Use removing & installing tool to press bearings in & out.



(2)

Install bearings so lubrication holes & grooves are alined. Leave clearances at ends of bearings where specified.

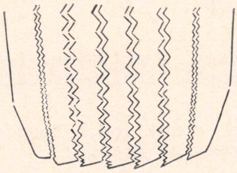
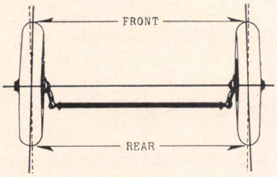
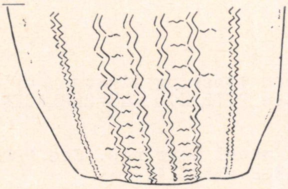
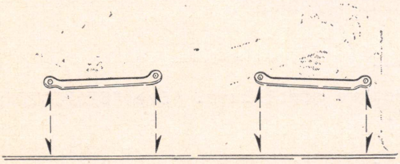
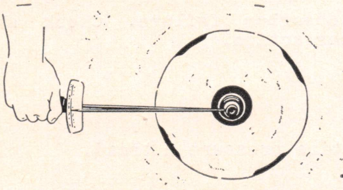
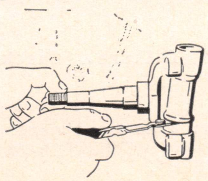


(3)

Carefully line ream or burnish finish the bushing type bearings to specified pivot pin fit.

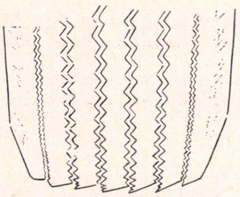
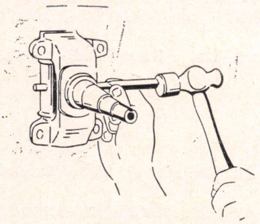
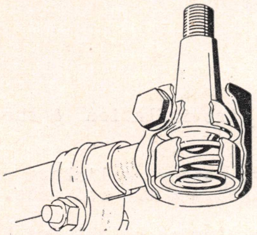
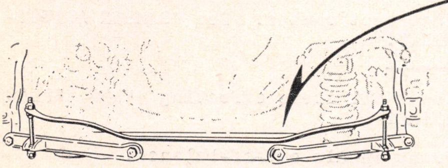
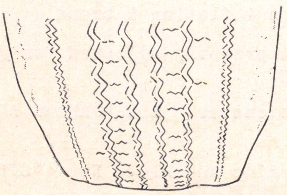
TROUBLE DIAGNOSIS

FRONT SUSPENSION

COMPLAINT	PROBABLE CAUSES & CORRECTIONS
Excessive Or Uneven Front Tire Wear. 	(1) Incorrect tire inflation. Inflate tire to recommended pressures. (2) Improper camber or caster. See "CAMBER-ADJUSTMENT" or "CASTER-ADJUSTMENT". (3) Improper toe-in or toe-out. See "TOE-IN ADJUSTMENT" or "TOE-OUT ADJUSTMENT".
Car Pulls To One Side.  	(1) Incorrect tire pressure. Inflate tires to recommended pressures. (2) Incorrect camber or caster. See "CAMBER-ADJUSTMENT" or "CASTER-ADJUSTMENT". (3) Incorrect toe-in. See "TOE-IN-ADJUSTMENT".
Car Wanders. 	(1) Check tire inflation & tire tread. (2) Wheels toe-out in straight-ahead position. See "TOE-IN ADJUSTMENT". (3) Incorrect or uneven caster. See "CASTER-ADJUSTMENT".
Low Speed Front Wheel Shimmy. 	(1) Check front tire inflation & the tire tread. (2) Worn or loose steering linkage parts. Check all linkage & tie rod ends. (3) Unequal front spring height. See "FRONT SPRING HEIGHT-MEASURE". (4) Incorrect camber. See "CAMBER ADJUSTMENT".
High Speed Front Wheel Shimmy. 	(1) Check all items affecting "LOW SPEED SHIMMY". (2) Front wheels out-of-balance. (3) Incorrect camber or caster. See "CAMBER-ADJUSTMENT" or "CASTER-ADJUSTMENT".
Steering Affected By Brake Application. 	(1) Check tire inflation & tread. (2) Brakes improperly adjusted or grease on lining. (3) Incorrect caster. See "CASTER-ADJUSTMENT". (4) Bent steering knuckle. See "STEERING KNUCKLE-REPLACE".

TROUBLE DIAGNOSIS

FRONT SUSPENSION

COMPLAINT	PROBABLE CAUSES & CORRECTIONS
Car Roughness Or Vibration. 	(1) Uneven tire wear. See "FRONT TIRE-VISUAL INSPECTION". (2) Worn or broken front wheel bearings. See "FRONT WHEEL BEARING-ADJUSTMENT". (3) Road surface condition. Test car on different types of road.
Hard Steering. 	(1) Check tire pressure & tread. (2) Tight king pin bushings. See "STEERING KNUCKLE BEARINGS-REPLACE". (3) Lubricate all the steering linkage & knuckle fittings.
Excessive Play In Steering Wheel. 	(1) Loose or worn steering linkage or tie rod ends. See "TIE ROD END-REPLACE". (2) Loose front wheel bearings. See "FRONT WHEEL BEARINGS-ADJUST". (3) Loose or worn steering knuckle pivot pins or bearings. See "STEERING KNUCKLE BEARINGS-REPLACE".
Poor Control Of Car On Turns. 	(1) Defective stabilizer. See "STABILIZER BAR". (2) Weak front spring. See "FRONT SPRING HEIGHT-MEASURE". (3) Shock absorber failure. Check shock absorber action.
Steering Wheel Kick Back. 	(1) Check tire pressure & tread. (2) Improper caster. See "CASTER-ADJUSTMENT". (3) Shock absorber failure. Check shock absorber action. (4) Bent suspension arms or steering knuckle. See "CAMBER-ADJUSTMENT" & "KING PIN INCLINATION-TESTS".

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